



**CORE LOGISTICS CAPABILITY POLICY APPLIED TO USAF COMBAT  
AIRCRAFT AVIONICS SOFTWARE: A SYSTEMS ENGINEERING ANALYSIS**

GRADUATE RESEARCH PROJECT

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AFIT/ISE/ENV/10-J02

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## **Abstract**

The 1985 National Defense Authorization Act required the U.S. Government to maintain the public capability to sustain military systems that play a role in war plans and contingency scenarios – referred to as “core”. This research analyzes application of this law to the modification of fielded USAF manned combat aircraft Operational Flight Programs (OFPs).

First, a review of the content and history of the law and implementing policies was performed. The intent of Title 10’s core requirement was analyzed with respect to the risk of relying on private sector depot maintenance in today’s environment.

Next, models were developed as a tool for determining whether OFP work is more appropriately designated as maintenance or development. The models were applied to current combat aircraft OFPs, and results suggest that most OFP modification is development and not maintenance. Foundational to the models, a common lexicon is proposed with definitions of “software maintenance” and other key terms.

Lastly, a new model for source of repair decisions is proposed which includes a risk analysis for all depot work, regardless of core designation. Beneficial to program offices, depot organizations, and HQ AFMC, this framework allows greater flexibility and cost savings by emphasizing competition based on cost effectiveness.

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# CORE LOGISTICS CAPABILITY POLICY APPLIED TO USAF COMBAT AIRCRAFT AVIONICS SOFTWARE: A SYSTEMS ENGINEERING ANALYSIS

## I. Introduction

*DoD increasingly relies on software to introduce or enhance performance of weapon systems, and making software adjustments is increasingly a key component of maintaining systems to prepare for emergency conditions.*

(Government Accountability Office, 2009)

*The role of software as the most critical part of weapons systems is growing. As an example, 80% of the functionality in modern-day aircraft like the F-35 JSF is dependent on software.* (Naval Air Systems Command, 2008)

### **Background**

The United States government has an interest in retaining control over and expertise in the maintenance and repair of weapons systems used in time of war or significant military action. The motivation for this requirement is mentioned in a single line of the law: to ensure a “ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements” (Title 10 U.S. Code, Sec. 2464, 2006 ed). This interest was expressed in the 1985 National Defense Authorization Act and codified into law, generating cascading layers of DoD and USAF policy detailing this interest and its implementation. Logistics capabilities required for the sustainment of weapons systems that play a role in major war scenarios are designated

“core” capabilities, requiring government facilities, government equipment, and government personnel to perform a significant portion of sustainment work.

In short, the government’s expressed interest in control over core logistics functions is insulation from the risk of total reliance on a private contractor for sustainment of critical weapons systems.

Over the past two decades, policies and regulations detailing the designation of systems as “core” and specifying their logistics planning requirements have grown in quantity and detail and have also changed in emphasis. The mid-1990s saw a significant push toward contractor logistics support. Then in the late 1990s, Congress expressed concern over excessive reliance on the private sector for depot-level logistics support of major weapons systems. As a result of this pendulum swing, the DoD published new guidance in 2002 allowing and defining public-private partnerships for depot-level maintenance of “core” systems. The 2002 guidance meant to satisfy the requirements of the law and retained the advantages of contractor involvement.

Implementation of the 1985 law has proved troublesome as long system development timelines span significant changes in technology, industry landscape, political winds, and policy emphasis. Compounding the challenge is the shift from hardware-centric military systems to systems permeated or dominated by software. Definitions of software maintenance and software sustainment in policy documents and military regulations are inconsistent at best and non-existent in some key documents. In some cases the requirement for the government to maintain software is added to existing hardware sustainment policy with a single sentence or cursory explanation.

Have the law, DoD policy, Air Force regulations, and logistics paradigms kept pace with the increasingly central role of software in weapons systems? Should the shift from protracted war toward smaller shorter conflicts result in changes to policy? Is the process by which maintenance workloads are designated as “core” adaptable and flexible to the myriad differences in system architecture and program history? Caught between the law and the constraints and expense of government depot-level maintenance, program managers are increasingly frustrated about how to transition from contractor to government logistics support, especially when government depot maintenance was not envisioned or planned at a program’s inception.



**Figure 1. Acquisition landscape**

The depot-level maintenance landscape today (Figure 1) is a confusing whirlwind of evolving policies, varying interpretation between the services, a shrinking industrial base, political intolerance of budget-overruns, and rapid technical innovation. In this

environment, implementing long-term logistics support for complex systems whose development may span a decade or more is a significant challenge.

The increasing role of software (Figure 2) compounds the problem because software is forced into existing hardware-centric paradigms and definitions. Aircraft avionics Operational Flight Programs (OFPs) are one example of software that is developed and sustained amidst a confusing mix of policies primarily geared toward hardware.

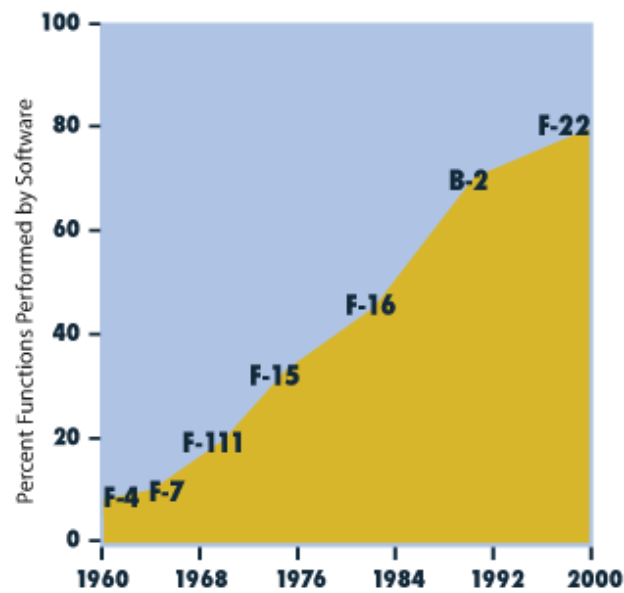


Figure 2. Increasing role of software in aircraft

## **Problem Statement**

The history and evolution of core logistics law and policy is difficult to comprehend yet critical to understanding and applying law and policy today. Definitions of key terms are inconsistent or lacking, further increasing the difficulty of understanding and applying policy.

This research addresses the history and motivation of core logistics law and policy and analyzes differences between hardware and software maintenance. This research also strives to allow better understanding of the complex web of law, policy, and practice. A common dictionary of terms is developed for use in policy and regulations, and models for differentiating between OFP maintenance and development are created. When combined with clear definitions, these models could bring rigor to avionics software source of repair decisions.

## **Scope of Research**

While some aspects of this research are applicable to software and hardware sustainment in general, the specific target is the development and depot level sustainment of the central integrating software in manned Air Force combat aircraft systems. The central integrating software is commonly called the Operational Flight Program.

OFPs are typically compilations of many lower level avionics software packages that together acquire, process, transmit, and display information, data, and signals in conjunction with aircraft specific hardware. A central OFP, run by the primary aircraft computer, integrates the subordinate OFPs which run various components such as a radar

or electronic warfare suite. Central or integrating OFPs are typically updated every one to several years and are developed for a specific aircraft major design series.

The scope of the research, therefore, is limited to the intersection of Title 10 core capability requirements, software, and manned USAF airborne combat systems. Figure 3 is a Venn diagram which visually depicts the research boundary.

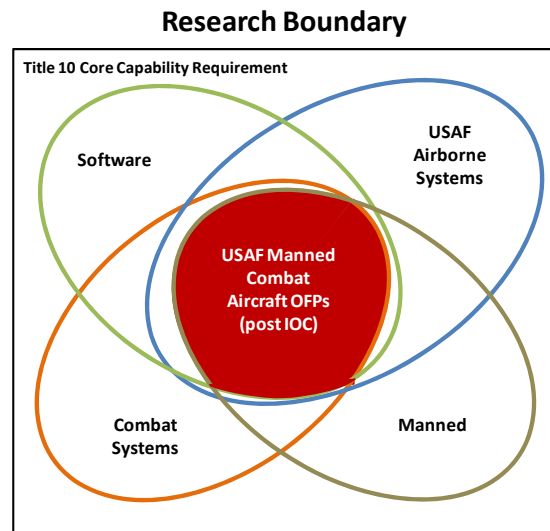


Figure 3. Research boundary

### **Conclusions Up Front**

Four conclusions are here stated and later defended, to highlight both the current challenges and potential solutions:

1. The taxonomy in use within the DoD, with regard to software maintenance, is inconsistent and vague. A clear, common, and consistent glossary should be included in DoD and Air Force policy documents. This research will propose clear definitions to guide implementation of policy.
2. Military aircraft OFP workload post-deployment is normally *not* software maintenance and should not be designated “core” by default. Additionally, the

source of modification for OFPs is typically conducted once in the software lifecycle. This research will develop a tool to aid in properly categorizing OFP modifications as either new development or maintenance. Additionally, this research proposes performing a source of modification decision prior to the fielding of each OFP.

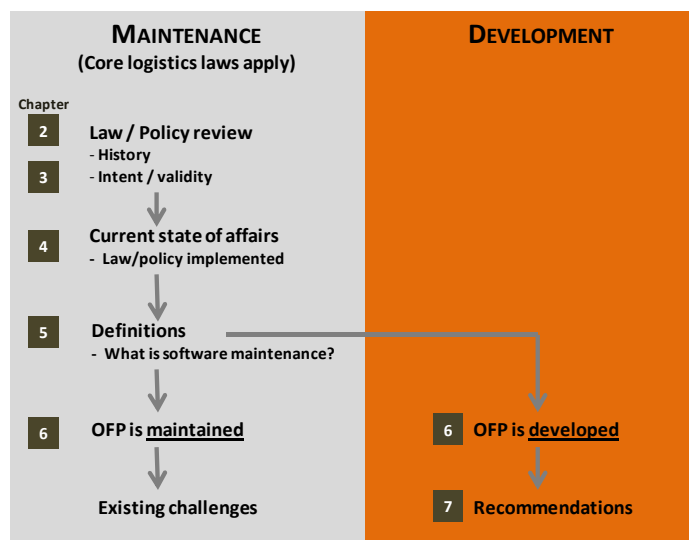
3. This research does not advocate replacing government depots with private depots. It does, however, advocate the continued cooperation between government depots and private industry through the implementation of Public-Private Partnerships (PPP). PPPs will allow for the smooth transition of work between private industry and government depots.
4. Title 10 does not currently allow for risk assessments or cost effectiveness to weigh in the source of repair decision. This research will show the risks associated with private sustainment of military systems has diminished since the law was written and therefore risk and cost effectiveness should now be considered when identifying core capabilities.
5. The requirement in Title 10 Section 2464 to establish an organic maintenance capability within four years of Initial Operating Capability (IOC) is arbitrary and best applied to hardware. Title 10 should be amended to require the DoD to identify depot workload allocations based on the particular attributes of the system under consideration.



## **Flow of the Argument**

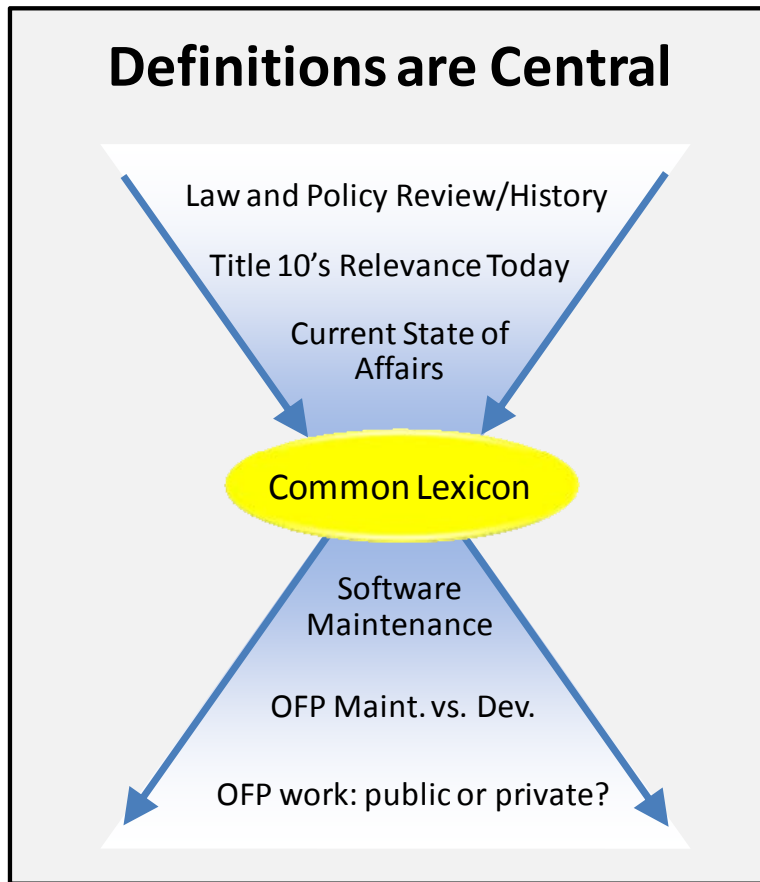
After laying the foundation with a review of relevant law and policy, the explicit and implicit intent of the requirement for government to maintain a core logistics capability is examined. The research then describes the current application of Title 10 requirements to software modifications and defines “software maintenance” by comparing and contrasting it with “hardware maintenance”. A common dictionary of terms is then proposed. Next, this understanding is applied to the issue of OFP updates, arguing that most (but not all) OFP development is development and not maintenance. We introduce a model that categorizes an OFP effort as primarily “maintenance” or “development”. Lastly these findings and model are integrated in proposing a more flexible model for OFP lifecycle planning—a model that satisfies the law, retains government depot maintenance capability, and allows for differences in OFP type and use. Figure 4 depicts the flow of this presentation pictorially with chapter numbers.

## **Flow of the Argument**



**Figure 4. Argument outline**

Another way of looking at the flow of this paper is depicted in Figure 5. This highlights the importance of definitions in understanding the history and future of software policy and education.



**Figure 5. Definitions are central**

## **II. Law and Policy History**

### **Introduction**

The last 15 years have been characterized by a tension between Title 10's core logistics requirement and Department of Defense policy. Agencies such as the Government Accountability Office are attempting to highlight law and policy disparities between two parties with different interests.

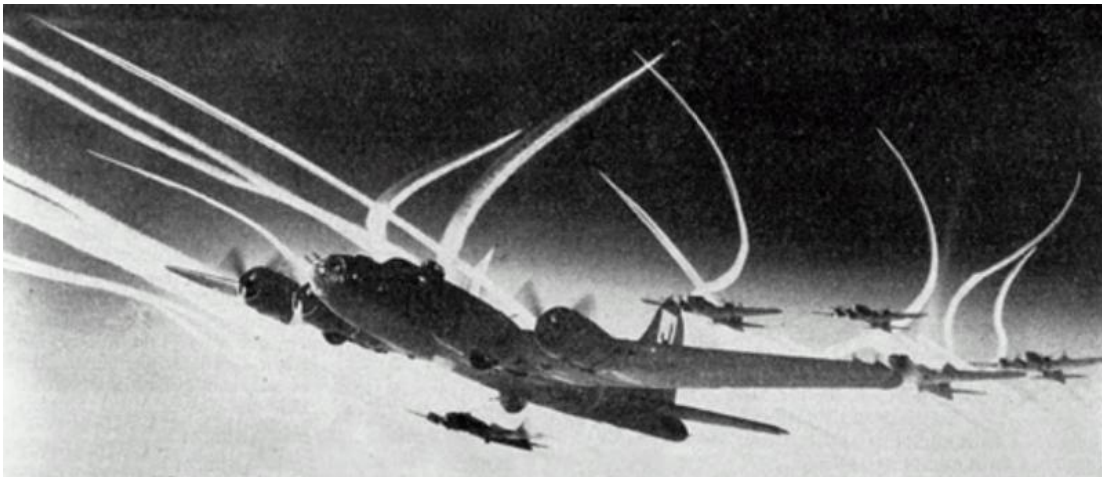
Newcomers to the core logistics discussion are in for a slow and confusing education if only *current* law and policy are considered. One encounters layers of evolving instructions with little commentary on why and when policy changes were made. The following summary is a primer of the law and its downstream policy.

Research methods used in this examination of law and policy history included a review of the text of Title 10 and its changes over time, a consolidation of existing analyses performed by the Government Accountability Office (GAO) and the Congressional Budget Office (CBO), and study of Congressional notes that are included in the text of public law which established Title 10 core logistics requirements. The text of the law and summaries of relevant policy documents and government reports are included in Appendices B-E.

### **Early Years**

The trail of depot maintenance challenges can be traced back to World War II (Figure 6). This is especially true for aircraft. The 1940's saw a fledgling aircraft industry pushed to its limits producing the vast quantities of aircraft required to fight the war.

Little excess capacity was available to maintain those aircraft (Congressional Budget Office, 1995). The solution at the time was to create an unspoken divide between the producer (the private sector) and the maintainer (the public sector).



**Figure 6. WWII bomber formation**

The historic notion that the government is solely responsible for depot level maintenance of aircraft therefore came about by the chance event of a major war coincident with an unprepared industrial base. This paradigm continues today even though the rationale behind the division of labor has long been forgotten.

### **Cold War**

Understanding the nature of military conflicts that immediately preceded the 1985 Title 10 organic core logistics law is critical to the task of interpreting and applying the law. The United States had a monolithic and clearly-identifiable enemy in the Soviet Union. American soldiers were frequently tested on their knowledge of Soviet guns, ships, tanks, and aircraft. Would-be American aces memorized silhouettes of Soviet

aircraft—Floggers, Fencers, Fulcrums, and Flankers. The U.S. military knew the enemy—his location, equipment, doctrine, and his uniform. The Cold War was conflict for the long haul. A war would be long and ugly, and U.S. aircraft might spend years in the European theater slogging it out against red stars painted on cold steel and aluminum (Congressional Budget Office, 1994).

Because of the protracted Cold War scenario, the American people could ill afford to chance their fate to the whims of a private contractor more interested in developing the next generation of aircraft than sustaining the current fleet. There was great concern that private depots would not be able to keep up with the surge in work expected if war broke out. Placing the depot maintenance under government control was the only way to assuage the risk (Congressional Budget Office, 1995).

Contrast this picture with today's wars, which differ greatly from war envisioned during the Cold War. What uniform does the enemy wear? Where is he hiding? Where will the next bomb blast be heard? Military engagements today are short but frequent, less predictable, with an elusive enemy, and no end is in sight. As evidenced by the personal military experience of this research team, our military aircraft rarely spend more than a few weeks or months in theater before rotating home for fresh crews and fresh jets.

Additionally, the nature of the industrial base has changed. Fewer new systems are being developed and, some would argue, shifting depot maintenance to the private sector is critical to ensuring the long term viability of the contractors (Congressional Budget Office, 1995). The economics of the modern world have more closely aligned the

interests of the government and private industry potentially reducing risks that were unbearable in the 1980s.

The nature of war has changed greatly between 1980 and 2010. The changes have informed the laws codified in Congress and the policies penned in the Pentagon. This study will highlight those changes and how they have often failed to keep pace.

### **Title 10 of the United States Code**

The requirement for the United States to maintain an organic depot maintenance capability began with the National Defense Authorization Act (NDAA) of 1985. As previously mentioned, the United States was firmly embroiled in the Cold War in 1985 and government run depots had been the norm since World War II. Why did the U.S. Congress see the need to *codify* a practice that was normative for nearly 45 years? Shortly after World War II, the DoD and the Air Force began shifting depot maintenance responsibilities to the private sector (Congressional Budget Office, 1995). This culminated with a DoD policy in 1982 restricting the amount of work done in government depots to a maximum of 70 percent. The 1985 NDAA can be viewed as a Congressional response to a perceived DoD trend towards privatization. Since 1982, detail has been added and allowable ratios between government and contractor depot maintenance varied.

These changes in the allowable proportion of work allocated to the government are here summarized (Government Accountability Office, 2008) and depicted in Figure 7:

- 1982 –DoD directed that services plan for not more than 70 percent of depot maintenance to be repaired at organic [military] depots.
- 1985 –NDAA required the government to maintain a core logistics capability.
- 1992 –NDAA set a 60 percent floor for organic depot maintenance.
- 1996 –DoD’s policy shifted to relying more on the private sector for depot maintenance.
- 1998 –NDAA established that no more than 50 percent of depot maintenance funding can be allocated to the private sector.
- 1998 –Definition of depot maintenance in Section 2460 of Title 10 expanded to include all depot level maintenance and repair workload regardless of location of where the work was performed and specifically included software maintenance.

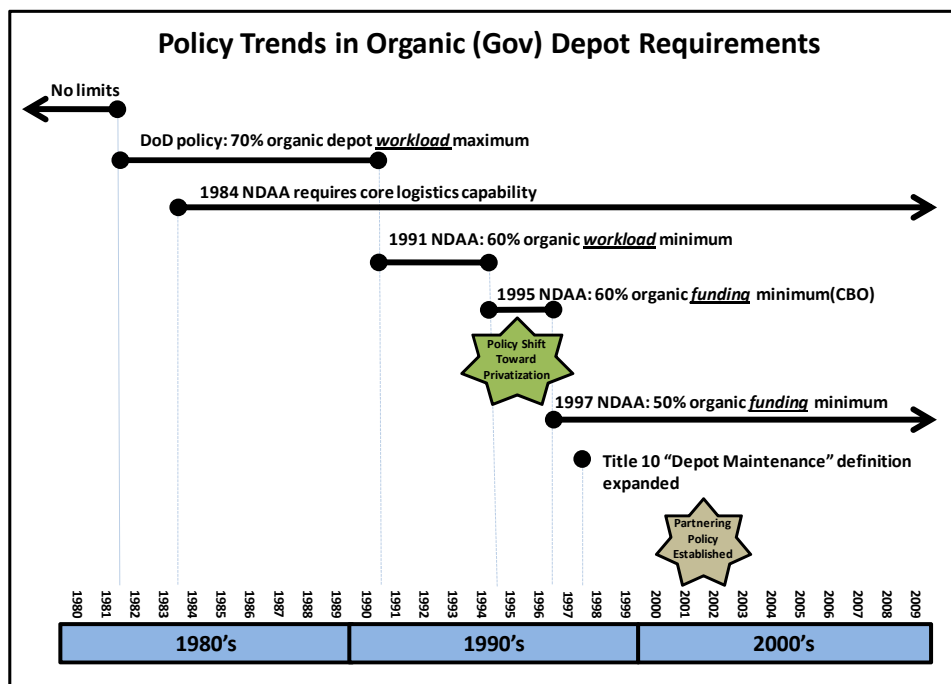


Figure 7. Policy trends in organic depot requirements

**Title 10 Sec 2464** ([link to full text](#))

Established in 1985, Section 2464 is foundational to the core logistics discussion. Section 2464 requires the United States to maintain an organic (government-owned) core logistics *capability*, consisting of the triad of government-owned equipment operated by government employees in government facilities. Section 2464 also gives the power of identifying core logistics capabilities to the Secretary of Defense and specifically mentions only a single motivation for this law: ensure a “ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements”. In addition to identifying core capabilities, the Secretary of Defense is required to identify the workload necessary to maintain these capabilities (Title 10 U.S. Code, Sec. 2464, 2006 ed).

Further, Section 2464 defines a “logistics capability” as those capabilities necessary to “maintain and repair” our weapon systems and other military equipment identified as necessary for the fulfillment of strategic and contingency plans prepared by the Chairman of the Joint Chiefs of Staff. In summary, this law requires that government depots have the capability to maintain all weapon systems or equipment that play a vital role in our war/contingency plans.

It is important to note that this law does not require the government to *perform* all maintenance and repair on critical military systems; it only requires the government to *maintain the capability* to maintain and repair. As will be discussed later, the workloads associated with this capability depend on expected workloads during time of



war/contingency and the government's ability to surge to higher workloads when required. Section 2464 requires that this core capability be established "not later than four years after achieving initial operational capability" (Title 10 U.S. Code, Sec. 2464, 2006 ed).

Interestingly, this foundational law does not refer to maintaining a core "depot" maintenance capability. It mentions only "maintenance and repair" in general, omitting the adjective "depot". However, the 1996 National Defense Authorization Act includes notes from Congress on Section 2464 which explicitly include the adjective "depot" in front of the term "maintenance and repair" (United States Congress, 1996). So while Title 10 does not include the adjective "depot", the intent of the law is clear. Section 2464 requires the government to maintain a core capability for *depot* maintenance and repair.

**Title 10 Sec 2460** ([link to full text](#))

For the first 13 years of its existence, Section 2464 was marred by confusion and loopholes that made its implementation troublesome. By 1998, the year section 2460 was added, the DoD had fully embraced a policy of privatizing depot maintenance (Government Accountability Office, 2008). Concepts such as Contractor Logistics Support (CLS) and Interim Contractor Support (ICS) were gaining ground and the DoD did not view these practices as depot maintenance. By not designating this work as depot maintenance, the DoD was able to simultaneously comply with the law and implement its privatization goals.

As mentioned previously, the law did not explicitly state its intent to specifically regulate depot level maintenance. This lack of specificity resulted in inconsistent application of this law. Additionally, the definition of what constitutes depot maintenance was not shared among all interested parties and allowed accounting loopholes for calculating the mix between contract and government work.

Section 2460 is important because it closed these loopholes by providing a definition of “depot-level maintenance and repair”. It was also significant because Congress publicly recognized the growing reliance on software within military systems. Finally, Section 2460 states that depot-level maintenance includes “all aspects of software maintenance” (Title 10 U.S. code, Sec. 2460, 2006 ed).

Highlights of Section 2460 include (Title 10 U.S. code, Sec. 2460, 2006 ed):

- The definition of “depot-level maintenance and repair”:
  - Material maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies
  - Includes the testing and reclamation of equipment as necessary
  - Does not depend on the source of funds for the maintenance or repair or the location at which the maintenance or repair is performed
- Depot-level maintenance and repair includes:
  - All aspects of software maintenance
  - Interim contractor support or contractor logistics support (or any similar contractor support), to the extent that such support is for the performance of services described in the definition above

- Exceptions
  - Procurement of major modifications or upgrades of weapon systems that are designed to improve program performance. A major upgrade program covered by this exception could continue to be performed by private or public sector activities.
  - Procurement of parts for safety modifications. However, the term does include the installation of parts for that purpose.

Significantly, this law uses hardware-centric language in the root definition of depot-level maintenance but then appends a statement that includes software maintenance within the scope of the root definition. By analogy, if the repair of a personal computer is formally defined as the repair or replacement of its various hardware components, it would not make sense to claim this definition includes the correction of software bugs. Or to turn the analogy inside out, if software maintenance is defined as writing new code to correct bugs discovered since initial software release, it would be confusing to claim that this definition of maintenance includes hard drive replacement.

The basic definition of depot-level maintenance in Section 2460 seems to have been written with hardware in mind. A line including software maintenance appears to have been added after the fact, indicating an understanding of the growing importance of software in military systems but a weak grasp of the unique nature of software maintenance.

In summary, Section 2460 provides a definition of “depot-level maintenance and repair” and states that depot-level maintenance includes “all aspects of software maintenance”.

**Title 10 Sec 2466** ([link to full text](#))

Section 2466 requires that a maximum of 50% of depot-maintenance and repair workload *funds* be used for non-government contract work. This portion of Title 10 has been used alternatively to encourage or limit the proportion of depot funds spent in the private sector. The 50% limit for government work was established in the 1998 NDAA—a change from earlier limits summarized in Figure 7. The Congressional record of debate that preceded passage of the 1998 NDAA reveals that the 50% limit was a compromise between two goals in tension: preserving public sector jobs while allowing the DoD the necessary flexibility to apply sound business practices in making source of repair decisions. Additionally, Section 2466 requires the Secretary of Defense to report annually to Congress on the DoD’s compliance with this requirement (Title 10 U.S. Code, Sec. 2466, 2006 ed).

**Title 10 Sec 2470** ([link to full text](#))

Added via the 1998 NDAA, this section of Title 10 states that in cases where competition is used to source depot work, government depots must be eligible to compete. Congress included this language because DoD had at times excluded government depots from competition out of a desire to shift work to private industry in hopes of keeping private industry viable (Government Accountability Office, 1998).

**Title 10 Sec 2474** ([link to full text](#))

The 1998 National Defense Authorization Act that established Section 2460 also established section 2474. As mentioned previously, section 2460 was primarily aimed at closing loopholes that the DoD used to allocate more depot work to the private sector. In

contrast, Section 2474 appears to be recognition by Congress that the DoD's efforts to cut costs by privatizing depot maintenance were not without merit. Section 2474 recognizes that a re-invigorated government depot system which embraces private contractors could provide effective and cost efficient depot maintenance at acceptable risk to the government. This tension is relieved through Public-Private Partnerships.

Section 2474 defines Public-Private Partnerships and allows government depots to partner with private entities that may then perform work related to the core competencies of the government depot.

The objectives of such partnerships, according to Section 2474, are:

- Maximize use of the government depots capacity
- Reduce cost of ownership of a government depot
- Reduce cost of products that are maintained or produced at the depot
- Leverage private sector investment in equipment recapitalization and promotion of business ventures
- Foster cooperation between the armed forces and private industry.

This portion of Title 10 is relevant to the discussion because it allows and defines Public-Private Partnerships, which are an increasingly common tool for leveraging the advantages of both organic and contractor depot maintenance. This option is critical to the analysis of which parties should perform OFP maintenance and development.

Secondly, Section 2474 requires that each government depot be designated a Center of Industrial and Technical Excellence in that depot's particular area of expertise,

effectively requiring the depots to specialize and become “recognized leaders in their core competencies”.

### **DoD Policy**

With this overview of Title 10’s direction, an analysis of the DoD’s policy can begin. As government agencies such as the GAO highlighted gaps between Title 10 and DoD policy, DoD policy documents have grown increasingly detailed in their instructions for implementation of Title 10’s maintenance capability requirement. Figure 8 depicts the relationship between DoD policy documents, upstream Title 10 sections, and downstream USAF instructions.

## Core Logistics Policy Tree

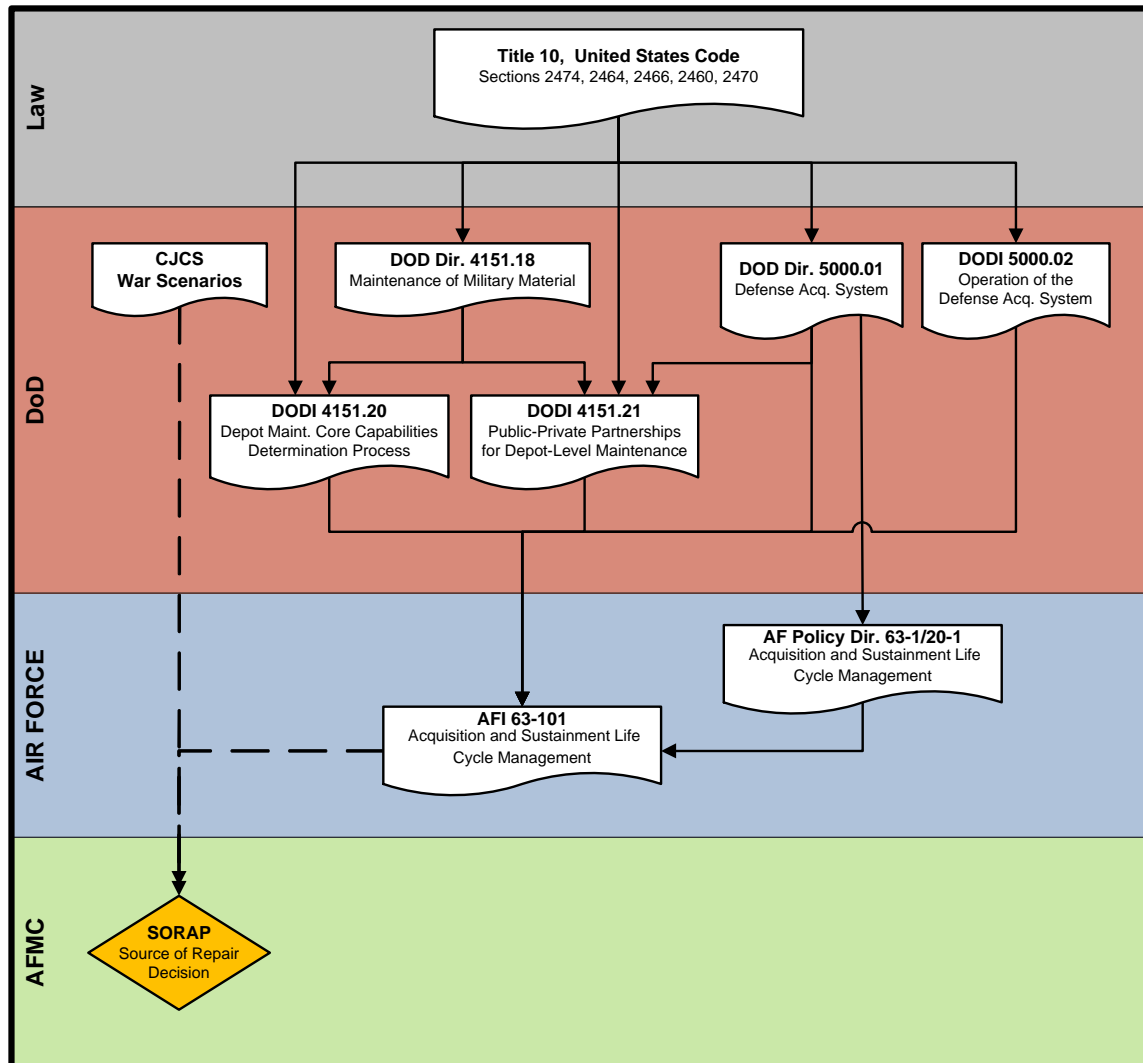


Figure 8. Core logistics policy tree

## **Reports by Government Agencies**

Numerous GAO reports and several CBO reports are cited in this research. While the GAO was primarily concerned with adherence to law and government insulation from logistical risks, the CBO focused on ways to perform depot maintenance as *cost-effectively* as possible. The CBO examined the genesis of the current depot maintenance system to find areas where it could be improved, identified the relevant attributes which would make one sector more cost effective than another, and offered conceptual options for analyzing workloads and assigning them to the different sectors.

From 1996 through 2009 the GAO was tasked by various National Defense Authorization Acts to report on DoD's core capabilities at least 14 times. Early GAO reports generally dealt with the growing trend of privatization in the DoD. Later GAO reports focused on DoD policies related to the 50-50 workload split mandated by Title 10 Section 2466. The most recent focus of the GAO has been on the DoD's ability to identify core capabilities.

GAO reports that analyze DoD's compliance with Title 10 are listed in Table 1 and summarized in Appendix E, which can be accessed via the hyperlinks in Table 1. Reading the report titles alone provides a cursory overview of trends in the public-private debate over the last 15 years. In summary, GAO and CBO reports recount the ongoing debate between Congress and the DoD regarding the intent behind Title 10 and its validity in today's world.



**Table 1. GAO reports pertaining to core depot maintenance capabilities**

<b>Year</b>	<b>Report ID</b> (hyperlinked to report)	<b>Title</b> (hyperlinked to annotated bibliography)
<b>1996</b>	GAO/T-NSIAD-96-148	Privatization and the Debate Over the Public-Private Mix
	GAO/NSIAD-96-165	DoD's Policy Report Leaves Future Role of Depot System Uncertain
	GAO/NSIAD-96-166	More Comprehensive and Consistent Workload Data Needed for Decision makers
<b>1997</b>	GAO/T-NSIAD-97-112	Uncertainties and Challenges DoD Faces in Restructuring Its Depot Maintenance Program
<b>1998</b>	GAO/NSIAD-98-8	DoD Shifting More Workload for New Weapon Systems to the Private Sector
<b>2000</b>	GAO/T-NSIAD-00-112	Air Force Faces Challenges in Managing to 50-50 Ceiling
	GAO/NSIAD-00-115	Air Force Report on Contractor Support is Narrowly Focused
	GAO/NSIAD-00-152R	Air Force Waiver to U.S.C 2466
<b>2001</b>	GAO-02-105	Actions Needed to Overcome Capability Gaps in the Public Depot System
<b>2006</b>	GAO-06-839	DoD Should Strengthen Policies for Assessing Technical Data Needs to Support Weapon Systems
<b>2008</b>	GAO-08-572T	DoD Needs to Reexamine Its Extensive Reliance on Contractors and Continue to Improve Management and Oversight
	GAO-08-761R	Issues and Options for Reporting on Military Depots
	GAO-08-902R	DoD's Report to Congress on Its Public-Private Partnerships at Its Centers of Industrial and Technical Excellence (CITEs) Is Not Complete and Additional Information Would be Useful
<b>2009</b>	GAO-09-83	Actions Needed to Identify and Establish Core Capability at Military Depots

## **The Push for Private Sector Sustainment**

Several GAO reports offer insight into the friction between the DoD's desires for greater flexibility afforded by privatization and Congress's desire to maintain strong core capabilities at government depots. The GAO moderated debate regarding privatization essentially began in 1996 when the DoD was looking to transform itself both in combat and logistic capability after the Cold War. As the number of major acquisition programs decreased, the DoD became concerned the industrial base could not be maintained and saw depot maintenance as a way to keep private industry viable (Congressional Budget Office, 1995). Additionally, proponents of privatization argued the private sector could perform depot maintenance with greater cost effectiveness compared to the public sector.

The DoD policy shift toward privatization in the mid 1990s was highlighted in the 1996 GAO report *DoD's Policy Report Leaves Future Role of Depot System Uncertain*.

Key points included:

- A desire for minimum core requirements.
- Redefining core requirements to allow for privatizing mission essential requirements previously defined as core.
- Limiting public depots from competing with the private sector for non-core workloads.
- Providing a preference for privatizing depot maintenance for new systems.

In contrast to the GAO's characterization, the DoD was not making unsupportable policy decisions. The 1995 report of the Congressionally established Commission on Roles and Missions of the Armed Forces completely rejected the concept of core logistics

capabilities and “...recommended outsourcing depot maintenance for all equipment, including all depot maintenance for new weapon systems to third-party providers” (Withers, 2000). This view was shared by the Defense Science Board, a civilian advisory panel to the DoD, which concluded “that DoD only engage in direct warfighting policy, decision making, and oversight activities and that all other activities, especially depot maintenance, be outsourced to third-party providers” (Withers, 2000).

A February 2000 article in *Army Sustainment* (the Army’s professional journal for the sustainment warfighting function) summarizes the trend toward privatization in this way:

Acquisition program managers decide on the source of repair for their weapon systems. Their decisions drive billions of dollars in support costs and affect near-term investments in support equipment, repair parts, training, and technical data (engineering drawings and technical manuals). In the recent past, acquisition program managers selected organic DoD maintenance depots for core equipment. However, it became obvious that commercial sources could execute depot maintenance work that exceeded organic capacities and capabilities; they also could do the work when DoD's capability had not yet been established. The result has been a trend toward greater private sector involvement in depot-level maintenance. Approximately 10 years ago, organic depots performed the maintenance for 75 percent of all equipment. Today, the private sector provides 40 to 50 percent of depot-level maintenance. (Withers, 2000)

An additional DoD policy change in the mid 1990s was to move source of repair decision authority from the service logistics chief to the program manager, which recognized the role of sustainment in the total lifecycle of a system (Government Accountability Office, 1996). However, this shift may have forfeited the knowledge and expertise logistics chiefs contribute to the sustainment of the depots themselves.

In contrast to proponents of privatization, the GAO concluded in its report titled *Privatization and the Debate Over the Public-Private Mix* that this shift toward privatization in DoD policy might exacerbate existing excess capacity problems at government depots, increasing inefficiency due to an underutilized depot maintenance structure (Government Accountability Office, 1996). Additionally, the GAO found DoD policy to be inconsistent with congressional guidance in the area of public-private competitions for non-core workloads (Government Accountability Office, 1996).

Another significant finding by the GAO was the impact of privatization on the ability of public depots to maintain capability in the area of new technologies. The GAO report titled *Air Force Report on Contractor Support is Narrowly Focused* highlighted this fact by including a memorandum from the Ogden Air Logistics Center to Air Force Materiel Command dated 9 Feb 2000 which stated:

Infusion of new technology workloads from new weapon systems is essential to maintain core. Therefore the future of the [air logistics center] is contingent upon acquiring workloads in each technical repair center that will continue to provide a viable organic source of repair for the using commands. If an [air logistics center] is determined core or best value in a particular technology, then any new weapon system acquired that has the associated technology should have the respective core allocation from day one of the sustainment life cycle. The core determination is weighted heavily towards older high surge workloads. Depots are provided new workloads often only after the original equipment manufacturer loses interest. (Government Accountability Office, 2000)

As an example of the DoD policy shift the GAO reported that by 1997, 52 percent of the new acquisition programs studied were either selecting or leaning towards private sector depot maintenance compared to 16 percent selecting or leaning towards public

sector depots (Government Accountability Office, 1998). Uncertainty with the policy created confusion and programs such as the C-17 delayed source of repair decisions for at least six years to allow logistics policy to stabilize (Government Accountability Office, 1998). Figure 9 summarizes this mid 1990s trend in program offices delaying source of repair decisions (Government Accountability Office, 1997).

<b>Sustainment Choices for Major Systems (1997)</b>			
<b>System</b>	<b>Leaning to Organic</b>	<b>Undecided/Deferred</b>	<b>Leaning to Contract</b>
<b>Army</b>			
Apache Longbow			X
Black Hawk	X		
Javelin		X	
JSTARS GSM			X
Paladin			X
<b>Navy</b>			
F/A-18E/F		X	
Seawolf		X	
T406 engine			X
V-22 Osprey		X	
<b>Air Force</b>			
AC-130U Gunship		X	
B-1B CMUP			X
C-17		X	
F-117 Engine			X
F-22		X	
JASSM			X

**Figure 9. Major acquisition program source of repair decisions - 1997**

The change in source of repair decision authority and the flux in policy was further evidenced by nearly 76 percent of program managers indicating they did not plan to make core designations or were uncertain about how or whether to consider core.

Some program managers responded that they were not sure what the term “core” meant (Government Accountability Office, 1998).

Congress clearly did not agree with DoD policy in its entirety and used the 1998 NDAA to create Title 10 section 2460 which established a definition of depot-level maintenance. The definition included “software maintenance” as depot level maintenance. Congress also amended Section 2464 by adding the requirement that the DoD-maintained core logistics capability be government *owned and operated*. The GAO offered its own expanded definition of depot maintenance in its report titled *Uncertainties and Challenges DoD Faces in Restructuring Its Depot Maintenance Program*, which reads:

Depot maintenance is a vast undertaking that requires extensive shop facilities, specialized equipment, and highly skilled technical and engineering personnel to perform major overhauls of weapon systems and equipment, to completely rebuild parts and end items, to modify systems and equipment by applying new or improved components, to manufacture parts unavailable from the private sector, and to program the software that is an integral part of today’s complex weapon systems. (Government Accountability Office, 1997)

The basis for much of the debate was the DoD assertion that it could reduce maintenance costs by 20-40 percent by outsourcing depot maintenance—a savings of billions of dollars (Congressional Budget Office, 1995). The GAO found inconsistencies in the cost comparisons used by the DoD, which lead the GAO to a more pessimistic expectation of cost savings associated with privatization. The GAO argued the DoD used outsourcing of vehicle maintenance and food services as the basis of cost savings. The GAO analyzed what it considered to be more similar private-public program

competitions and came to a different conclusion: public depots were as competitive as the private sector and in many cases were the more cost effective option (Government Accountability Office, 1996):

- 67% of competitions were won by the DoD with the average bid 40% lower than the closest competitor.
- 23% of the programs showed no private bids were offered and 35% included only one private bid.
- 62% of items repaired by both private and public depots were maintained less expensively in the public sector.

While Congress clearly was not comfortable with the DoD's preference for private depots, they did recognize a role for private depots in the overall DoD sustainment plan. This was reflected in the 1998 NDAA which amended Title 10 Section 2466 to allow the DoD use of up to 50 percent of depot maintenance funds for private sector work (up from 40% previously).

### **Title 10 Changes That Allowed More Private Sustainment**

In its 1995 report titled *Public and Private Roles in Maintaining Military Equipment at the Depot Level* the CBO noted that in the Air Force the division between private development and public sustainment evolved primarily out of necessity. The aviation industry in the 1940's was in the process of increasing its capacity and could not yet handle both production and maintenance functions simultaneously. The public depot filled the capacity gap in the private sector. In the years after the war the Air Force began to slowly move towards contract depot maintenance due to a lack of facilities and skilled maintainers in the public sector (Congressional Budget Office, 1995).

Prior to 1982 there was no legal limit on the amount of work done in the private sector. This research team surmises a limit did not exist because nearly all work was voluntarily conducted within public depots, although this is not explicitly stated. Then by 1982, the DoD directed that not more than 70 percent of work be done in public depots (Government Accountability Office, 2008). The rationale for this policy is not clear, but it is reasonable to assume the DoD was attempting to create competition for work to help decrease maintenance costs.

The limit changed again in 1991 (Government Accountability Office, 2008). But this time instead of placing a limit on the government's share of depot work, Congress placed a minimum on the government's share of depot work. Title 10 was amended to include a 60 percent organic workload floor – presumably in response to an increasing shift towards privatized maintenance. By 1996, DoD policy had completely shifted towards privatization. Complying with the 60 percent government workload minimum became increasingly difficult (Government Accountability Office, 2008).

By 1997, the Air Force was not only unable to meet the 60/40 mandate, but could not even reach 50 percent government workload (Government Accountability Office, 1996). The GAO projected that by 2001 the Air Force would only be able to achieve a 46/54 split, with the majority of work funds allocated to private industry. The reasons cited for the low percentage of public sector funding were a combination of DoD policy and closing of multiple government depots by the 1995 Base Realignment and Closure (BRAC) process (Government Accountability Office, 1996).



The DoD then called for a complete repeal of the 60/40 requirement arguing it was arbitrary and prohibited sound business practices. The GAO disagreed, contending that repealing the 60/40 rule would encourage further privatization which could result in higher depot maintenance costs by eliminating competition from the public sector, and increased readiness risks due to mission-essential work being transferred to the private sector (Government Accountability Office, 1996). Congress, in an apparent compromise, lowered the minimum public share of depot maintenance funds to 50 percent. These changes in the legal ceilings and floors on government depot work are depicted in Figure 10.

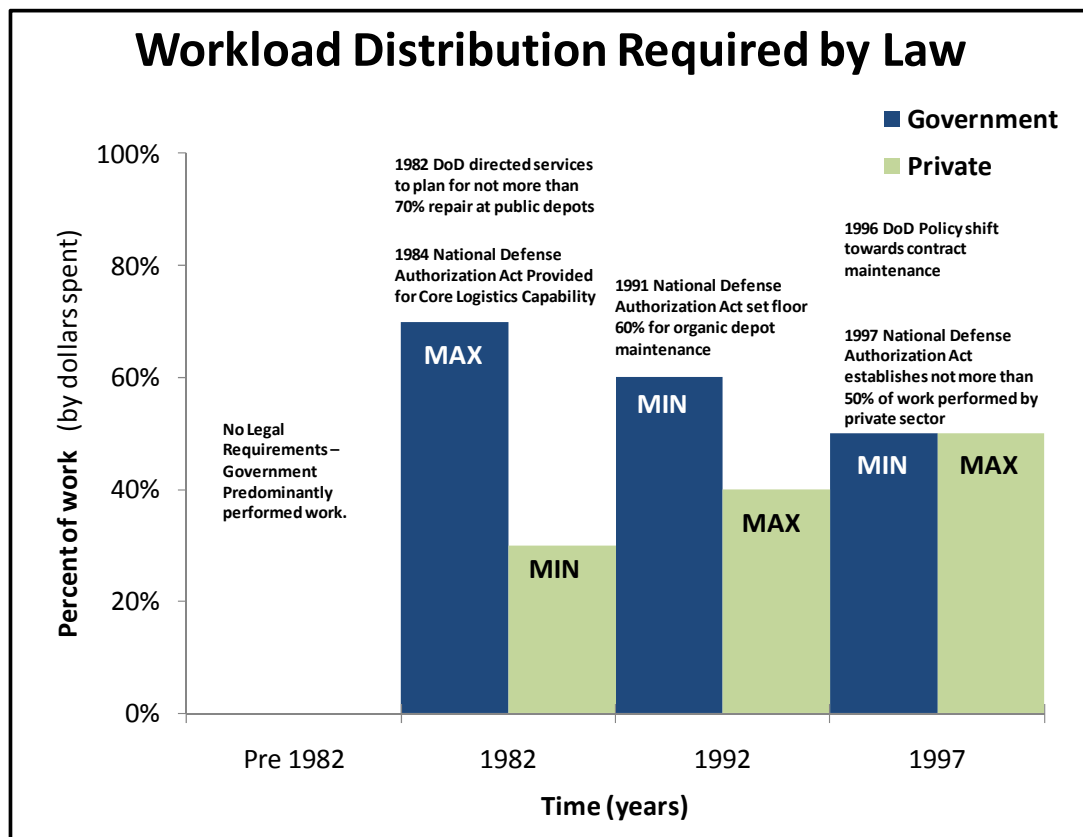
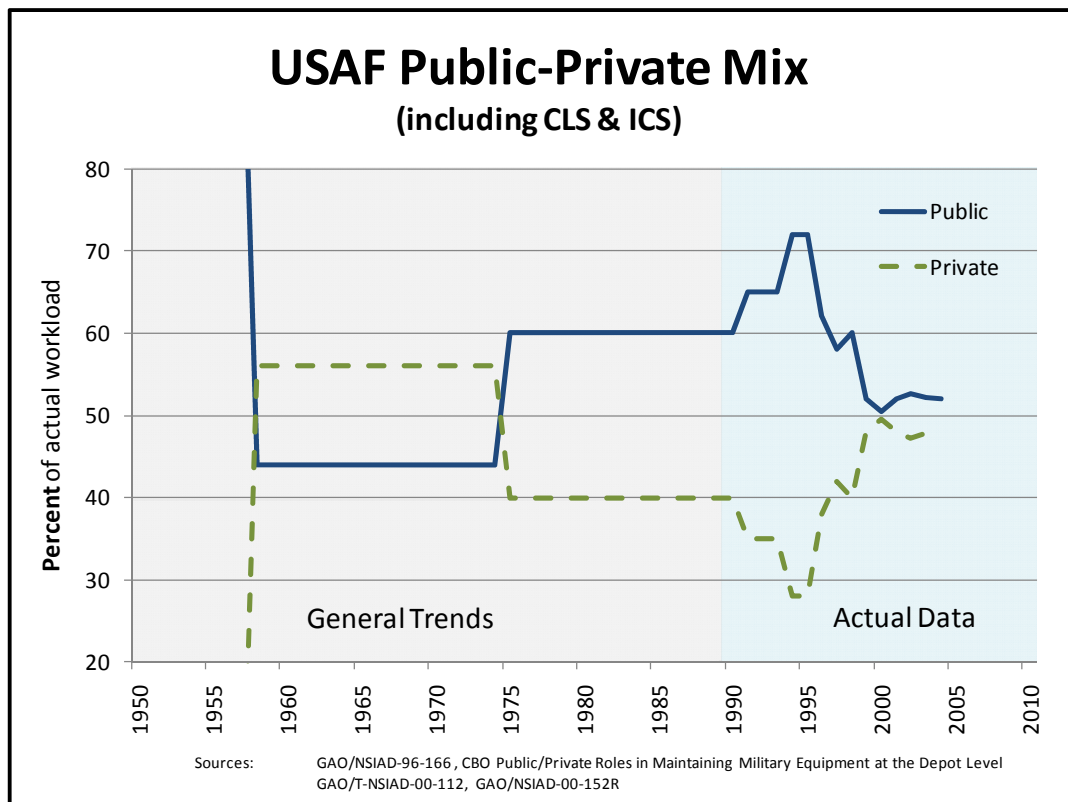


Figure 10. Workload distribution required by law.

The shift towards the private sector continued, however. Figure 11 depicts the proportion of Air Force workload performed by government and private sectors during this period of flux in Title 10 workload funding limits. Note that by 1999 the Air Force consistently failed to reach the requirement for a minimum 50 percent government allocation of workload funds.



**Figure 11. Proportion of depot work in public and private sectors**

In summary, the 1980s and 1990s saw significant swings in emphasis between public and private depot work. The changing emphasis undoubtedly impacted key lifecycle decisions of many programs as they elected to wait for the policy to stabilize before making long-term source of repair decisions.

### **Riding the Sine Wave: F-22 Logistics Planning**

As a brief case study, the F-22 provides a good example of a program caught between shifting policy and the need to plan for the future. F-22 flight testing began in the mid 1990s and plans were being developed for long-term depot level maintenance. During this time the Air Force Chief of Staff directed the F-22 program office to consider private logistics support as a means for cutting cost (Government Accountability Office, 1997). According to a 2009 interview with the F-22 program office, as a result of the push for private sustainment the F-22 program in the mid-1990s halted government depot preparations and stopped generating Logistics Support Analysis (LSA) data.

By 2002, the pendulum had swung back the other way, and AFMC designated the depot maintenance of most F-22 subsystems as a core organic logistics capability in accordance with Title 10 (F-22 Acquisition Strategy Panel, 2007). The F-22 was declared to have Initial Operational Capability (IOC) in Dec 2005 and the four year deadline for transition from interim contractor logistics support to organic sustainment loomed.

As evidenced by the F-22, the development time of military aircraft is on the rise. F-22 IOC was declared 14 years after the 1991 down-select contract award to Lockheed. Policy changes early in this period prevented early depot maintenance planning, causing an expensive catch-up game in the early to mid 2000's. In addition to changes in the legally required division of labor between public and private sectors, confusion existed over the identification of core capabilities.

## **What Are Core Capabilities?**

The central hurdle for the DoD in the late 1990s was establishing clear guidance on the identification of core capabilities for depot maintenance (Government Accountability Office, 2001). There lacked a systematic and consistent approach to identifying which logistic capabilities should be maintained in the public sector and which capabilities are better suited to competition in the private sector. As a result, processes varied from service to service. Some included software while others excluded it, and workload calculations required by the 60/40 and later 50/50 laws were not consistent (Government Accountability Office, 2001).

In a 2001 report the GAO reported that government depots were ill-equipped to maintain their core capabilities due to a lack of long-term strategic depot planning on the part of the DoD (Government Accountability Office, 2001). A high average age in the workforce, aging equipment, and a lack of capital investment called into question the long term viability of government depots.

Today the government depots are fewer in number but still hard at work. And yet the challenge of identifying core capabilities still exists. Software maintenance is a clear example of the lack of standardization and direction across the DoD. The Navy continued to exclude software from core requirements into 2009 while the Air Force included software (AFMC/A4DC, 2009). In 2009 a GAO report highlighted the Navy's exclusion of software from core workload calculations, and the Navy began the transition toward including software maintenance as a core capability (Government Accountability Office, 2009).

### **“Like” Workloads in Achieving Core Capability**

An additional area of concern is the DoD’s use of “like” workloads to satisfy core logistics requirements. For example, the DoD used workload on the C-141 and C-5 to satisfy core capability workload on the C-17 (Government Accountability Office, 2001). The GAO did not believe this practice truly established a core capability nor met the intent of the governing law. The DoD’s response was to provide an analogy of an auto mechanic who can perform work on Chrysler, Ford, and General Motors products, if the mechanic has tools, facilities, and knowledge. They asserted the skills, facilities, and knowledge are transferable and that the same holds true within the DoD. The policy of using like work continues within the Air Force (Government Accountability Office, 2001).

### **Law and Policy Summary**

The general trend in division of depot maintenance workload between the government and private industry from the mid 1990s to the present is from public sustainment to private sustainment. Two foundational requirements of Title 10 established in 1985 continue to be challenging to implement.

First, the DoD has been slow to clearly identify its core logistics capabilities. Services have interpreted law and policy differently, particularly in the area of software maintenance. The lack of clear definitions in policy documents is central to this problem.

Second, Title 10 has incrementally decreased the minimum share of depot workload funds that must be allocated to government depots. Yet the Air Force has struggled to meet the legal minimum as depot workload was increasingly allocated to the

private sector during the 1990s. The debate over the relative advantages of public or private depots continues, and the services are increasingly being held accountable for Title 10 compliance.

With this survey of law and policy history complete, it is time to examine the current state of affairs. How is core policy implemented today? First, the relevance of Title 10's core logistics requirement in today's environment is examined. Next, the current source of repair decision process is explained by means of functional and process models.

### **III. Relevance of Title 10's Organic Maintenance Requirement**

#### **Introduction: Examining Intent?**

Laws are written for specific reasons in a specific context. If any law is to remain relevant and applicable into the future, it must be periodically assessed and changed when and where needed. The motive of an existing law provides the necessary context for performing such an assessment. Therefore, before proposing changes to the text of the Title 10 law or changes to policies that implement the law, examining the motives behind the law is critical.

Research methods employed in this examination included an analysis of Title 10 itself, a review of congressional debate preceding passage of the law and its changes, and a study of reports on this issue published by the Congressional Budget Office and the Government Accountability Office.

#### **The Intent of Title 10**

Why does Title 10 Section 2464 require the government to maintain a capability to maintain and repair military systems used in our major war scenarios? Answering this question is vital in determining the scope of the law's application. A single explicit reason is provided in the text of the law itself (emphasis added):

It is essential for the national defense that the Department of Defense maintain a core logistics capability that is Government-owned and Government-operated (including Government personnel and Government-owned and Government-operated equipment and facilities) *to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization,*

*national defense contingency situations, and other emergency requirements.* (Title 10 U.S. Code, Sec. 2464, 2006 ed)

The explicit motivation is to ensure a ready and controlled maintenance capability. The government does not have control over the private sector and can therefore not ensure that industry is ready to perform the sustainment work needed in time of war. While this makes good sense on the surface, it generates several more questions.

### **Does Title 10 Specifically Refer to Depot Level Maintenance Only?**

While the language of Title 10 does not include the adjective “depot”, the congressional record reveals that depot maintenance was in mind here. For example, PUBLIC LAW 104–106—FEB. 10, 1996, which constituted the 1996 National Defense Authorization Act, includes the following language (*italics added*):

(a) FINDINGS.—Congress makes the following findings:

- (1) The Department of Defense does not have a comprehensive policy regarding the performance of *depot-level maintenance* and repair of military equipment.
- (2) The absence of such a policy has caused the Congress to establish guidelines for the performance of such functions.
- (3) It is essential to the national security of the United States that the Department of Defense maintain an organic capability within the department, including skilled personnel, technical competencies, equipment, and facilities, *to perform depot-level maintenance and repair of military equipment* in order to ensure that the Armed Forces of the United States are able to meet training, operational, mobilization, and emergency requirements without impediment.



(4) *The organic capability of the Department of Defense to perform depot-level maintenance and repair* of military equipment must satisfy known and anticipated core maintenance and repair requirements across the full range of peacetime and wartime scenarios. (National Defense Authorization Act for 1996, 1996)

The Congressional record clearly states that the context of Section 2464 is *depot*-level maintenance. Why the law itself does not include the adjective “depot” is unknown. All parties interviewed as part of this research considered the Title 10 core maintenance capability requirement to be in the context of depot-level maintenance only. Perhaps the ambiguity in the law does not cause interpretation problems because field/unit level maintenance is typically organic, and the lines between intermediate-level maintenance and the other two levels are fast disappearing.

The other sections in Title 10 clearly show that depot-level maintenance is the context of Section 2464, and so does DoD policy. DODI 4151.18, the foundational DoD instruction which implements Title 10 Section 2464, specifically applies Section 2464 to *depot* maintenance.

It is DoD policy that... Initial maintenance programs shall... Identify *depot* maintenance core capability requirements, as required by reference (e) [Section 2464 of title 10, United States Code] (italics added) (DODD 4151.18 Maintenance of Military Materiel, 2004)

In short, DoD policy references Section 2464 as requiring the DoD to identify *depot* maintenance core capability requirements, while Section 2464 does not use the term “depot” at all. Because DoD policy sets the direction for Air Force’s regulations, the designation of workloads as “core” and the calculation of labor hours required to

maintain a core logistics capability are therefore solely in the context of *depot* maintenance.

### **Is Reliance On the Private Sector Too Risky?**

Requiring the government to maintain a ready and controlled maintenance capability implies it is *too risky to rely on the private sector* for this work during war or contingency operations for a variety of reasons: private companies can fail, their employees may go on strike, or the profit motive may pull a contractor's attention in directions other than that of sustaining existing military systems.

In the 1990's, the CBO conducted at least two reviews of the role of private depots in the maintenance of military systems. The analysis focused on relevance of public sector depots in the post-cold war era, the relevant attributes of each sector, and the cost effectiveness of various depot options. The following analysis is a digestion of CBO reports.

In the mid-1990's, a debate between Congress and DoD concerning the roles of government and private sectors, with regard to depot maintenance, was building. The reassessment of industry's role in depot level maintenance of military materiel was a contentious issue. In the wake of the Cold War, the premise that the DoD required a "ready and controlled" organic source of maintenance was called into question. The DoD argued that "the depots were necessary to protect against the risk that contractors might be either unable or unwilling to respond immediately to DoD's requirements for maintenance during a war" (Congressional Budget Office, 1995). The DoD would later

reverse their stance on this issue and champion a greater role for private depots in the sustainment of military systems.

But the shift in policy in the 1990's towards a two major regional war scenario may have invalidated the Cold War premises. In fact, the CBO postulated that in these types of wars (such as OPERATION DESERT STORM), the duration of the conflict would be sufficiently short that the bulk of system repairs would actually occur after hostilities terminated:

The risks of using private-sector contractors might be less severe in the regional conflicts for which the military now plans than they were in the Cold War scenarios. Depot-level maintenance during relatively brief regional conflicts would focus primarily on repairing components. The surge in maintenance on major end items would not reach its peak until the conflicts were over and DoD could return the damaged equipment to the United States. (Congressional Budget Office, 1995)

Additionally, the CBO pointed out that, unlike World War II or Cold War scenarios, today's national industrial base would not have to fully mobilize to support wartime production and would therefore have capacity to support system maintenance.

As components become more reliable and the size of maintenance workloads declines, the services must increasingly balance the risk of relying on contractors for repairs against the cost of duplicating the capabilities of those contractors in public depots. The core method, which neglects costs and assumes that private maintenance is always too risky for mission essential equipment, provides no guidance about how to make those judgments. (Congressional Budget Office, 1995)

Since the CBO made this assessment, the environment has changed more as has begun to move away from the two-front major war paradigm to a more flexible

engagement scenario with a greater variety of enemies using an increasing variety of means. The draft 2010 Quadrennial Defense Review abandoned the two major theatre war strategy. While the final version reinstated the two theatre strategy, DoD's strategy expanded to reflect our current environment:

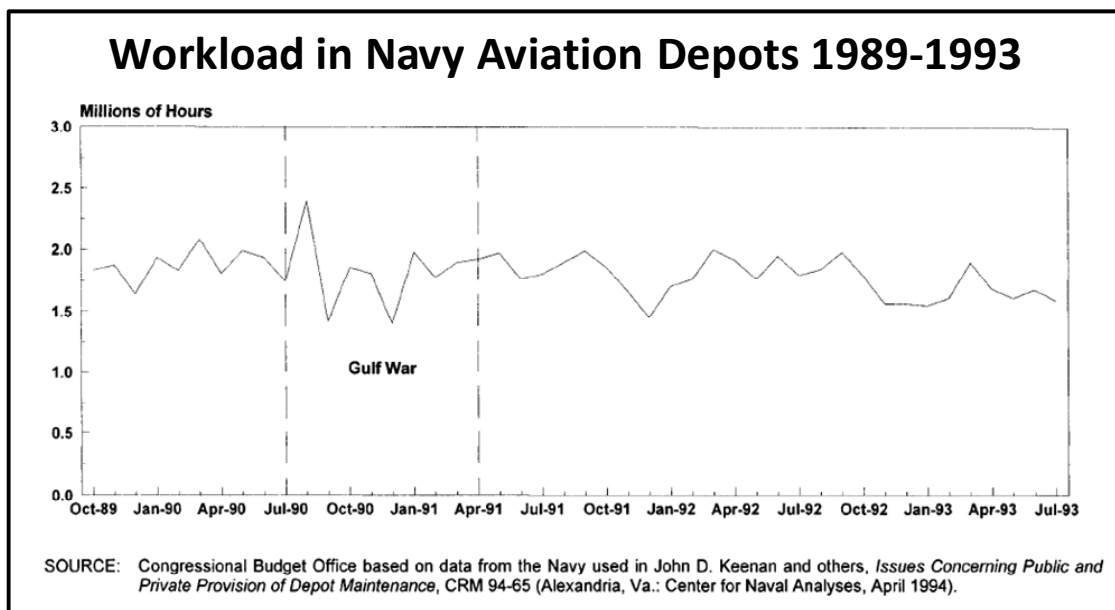
In the mid- to long term, U.S. military forces must plan and prepare to prevail in a broad range of operations that may occur in multiple theaters in overlapping time frames. This includes maintaining the ability to prevail against two capable nation-state aggressors, but we must take seriously the need to plan for the broadest possible range of operations- from homeland defense and defense support to civil authorities, to deterrence and preparedness missions-occurring in multiple and unpredictable combinations... (Quadrennial Defense Review Report, 2010)

This informs a related question: if the government is required to maintain the *capability* to perform depot maintenance, what situations would require the government to exercise its capability and actually *perform* the maintenance and repair? In other words, what would the war or contingency look like and how would it differ from peacetime? Is there today a distinction between wartime and peacetime?

### **War and Peace: Blurring the Lines**

The calculations used to determine the amount of work required to maintain a core capability are built on the premise that during times of war a depot will be required to surge to higher workloads to meet increased demand. The expected increased workload during times of war is a key component of the perceived risk of privatizing mission essential workloads. The fear is the government will have no power to require a contractor to increase their output. These fears appear to be unfounded in the context of

modern wars, however. Figure 12 charts the workload in Navy aviation preceding and following the 1991 Gulf War (Congressional Budget Office, 1995). The graph shows a sharp increase in workload during the OPERATION DESERT SHIELD portion of the conflict with a sharp decrease in work in the period leading up to the war itself. Overall, the average workload was not significantly affected by this conflict compared to peacetime workloads.



**Figure 12. Workload (Direct Labor Hours) in Navy aviation depots, October 1989 to July 1993**

Following the US liberation of Kuwait in 1991, military systems were used around the clock during 10 years of no-fly zone enforcement over Iraq. OPERATION ENDURING FREEDOM commenced in 2001 and continues to this day with every branch of the US military actively engaged. Military intervention in Somalia and the 1999 air war in Yugoslavia are further examples of military activity in the last two decades. Since the end of the Cold War 20 years ago, our Armed Forces and their

systems have been engaged around the world. A recent speaker at a conference on the topic of war and peace summarized the new landscape as follows:

Periods of peace and war therefore have come to be representative of strong nations or unified blocs of state power. Seldom has there been a threat that operated well outside the parameters of the system. The rise of Al Qaeda and the response by the United States is that it is a fundamental break with that historical past. Although currently the United States and its allies are involved in a global war against terrorism that maintains two active military fronts and a constant state of awareness, there has not been an official declaration of war by the United States Congress. The lines of war and peace blur further as the military services of the U.S. and its allies continue to conduct combat operations... (Kalic, 2010)

Gone is the Cold War paradigm of protracted large-scale conflict. Today's wars are fundamentally different: shorter, more frequent, overlapping, with diverse and difficult to identify adversaries. An unpredictable fast-changing environment demands a more flexible law—a law that is not built on clear transitions from peacetime to wartime with associated surges in depot workload. Over the last 20 years, both the military and industry have been continually engaged in waging and supporting military conflicts. Additionally, reliance on the private sector extends beyond depot maintenance. Private industry is the origin of the parts supply chain.

### **Private Sector Supply Chain**

Aside from relying on contractors for depot maintenance, is it realistic for the DoD to *not* rely on the private sector for sustainment tasks such as supplying new parts? If the motive for Title 10's core capability requirement is to shield the government from

the risk of relying on private sector maintenance, how can this be accomplished when many of the spare parts used in sustainment come from private industry?

...at least since World War II, DoD has depended on private production to supply virtually all of the consumable goods (for example, food, clothing, fuel) and most of the spare parts and weapon systems that it uses.  
(Congressional Budget Office, 1995)

As the CBO stated, the military relies heavily on private industry for spare parts. And this is especially true in today's high-tech systems where the military depot may be able to repair a Line-Replaceable-Unit, but must rely on circuit boards and other electronic components supplied by private industry. When aircraft sub-systems consisted primarily of stamped, bent, or formed metal components, they could be repaired at a government depot. But today's aircraft carry numerous sealed LRUs that are regularly shipped to the manufacturer for repair or replacement. The GAO reported in 1997 that, "Due primarily to a shortage of spare parts, Air Force aircraft mission capability rates have declined in recent years from 84.6 percent in fiscal year 1990 to 74.3 percent in fiscal year 1998" (Government Accountability Office, 1997). They also reported "The other major cause of parts shortages in September 1997 was the depot maintenance activities' inability to accomplish timely repair for 53 items reviewed. A major reason for this situation was the shortages of component parts to fix broken repairable items" (Government Accountability Office, 1997).

The F-15C APG-63V1 radar provides an example of reliance on private companies for LRU replacement and repair. As briefed in 1999, a partnership between Raytheon and the Air Force was established in which, "LRU's are to be shipped to

Raytheon, repaired, and returned to Air Force stock within 20 days overseas, 15 days CONUS from time of removal from aircraft” (Reid, 1999).

The GAO also reported that the shortage of spare parts was often caused by inaccurate forecasting of parts inventory requirements (Government Accountability Office, 1999). As the military is involved in an increasing variety of conflicts in diverse locations, it is likely that this challenge will not go away. The military will have to buy parts and components from the private sector *during* periods of military conflict.

It is therefore clear military depots will continue to rely on the private sector during wartime; the primary risk Title 10 Section 2464 was intended to protect against. Title 10’s explicit motivation of reducing the risk of reliance on the private sector is not realistic. This is yet another reason for re-addressing the motive behind the core capability laws. The law should have clear motives that are valid in today’s environment. *Apparent* risk of reliance on the private sector should not be given priority in the source of repair decision process while other factors such as *actual* risk or cost-effectiveness are ignored.

Since the DoD has successfully relied on the private sector during continual military conflict since the Cold War, what factors other than private sector risk should be considered in making source of repair decisions? DoDI 4151.20 names one other factor: best value (cost-effectiveness).



### **Should Cost-Effectiveness be Considered?**

Because risk was the primary criterion used by the DoD to determine source of repair in the 1990's, cost effectiveness carried little weight in decision making, but could play a larger role in future determinations of the appropriate source of repair (Congressional Budget Office, 1995). It is therefore important to understand the relevant attributes of the public and private sectors that affect their cost effectiveness.

The three relevant attributes of any depot with respect to cost effectiveness are (Congressional Budget Office, 1995):

- 1) Experience maintaining certain systems
- 2) Size of facilities/state of the art repair technologies
- 3) Size of workflow

For the first attribute, the CBO used the example of C-141 wing box repairs for which the government depot was the least costly source. An independent accounting firm found the 20+ years of experience the government had in maintaining the C-141 gave the government an inherent advantage over the private sector. In fact, the CBO found a given sector tended to win 68 percent of competitions for work which had been previously accomplished in that sector (Congressional Budget Office, 1995).

The second attribute entails the infrastructure of depots in terms of personnel, facilities, and state of the art equipment. The CBO found this to be "...consistent with economics literature" which suggests that in-house producers of a good or service will typically use more highly specialized capital and production processes than do other suppliers, who try to reduce risk by using general industrial assets and processes that may be

less efficient but have more alternative uses (Congressional Budget Office, 1995). The DoD has a distinct advantage over the private sector in this respect. The DoD generally has well-established facilities and state of the art technologies for repair that may not exist in the private sector because of the cost and risk associated with these items.

Finally, the CBO cites the large and steady workflow in the public depots as another factor influencing cost effectiveness. They argue that in many cases conducting modifications and routine maintenance simultaneously is more cost effective (Congressional Budget Office, 1995). Unfortunately, combining modifications and maintenance functions masks the potential for another sector to potentially do maintenance work more cost effectively in the future.

The CBO cites economic literature that emphasizes that the choice between in-house and contract sources is a choice between imperfect alternatives. They list the following factors that might make the private sector more attractive (Congressional Budget Office, 1995):

- Workloads for which the DoD could develop and use standard contracts.
- Workloads for which the output could be easy to evaluate.
- Workloads for which competition in the private sector was possible.
- Workloads that private firms can combine with new development or commercial repairs.

### **Summary: Is Title 10's Organic Core Capability Requirement Appropriate Today?**

In summary, Congress and the DoD should begin the larger discussion about the motivation behind the core capability requirement and discuss their validity in today's environment. This discussion would likely meet Congressional resistance because of one motive for keeping this organic requirement: jobs. The Congressional record over the last 15 years clearly reveals an understandable desire on the part of its members to keep government depots in place and not do anything that might decrease their workload or threaten jobs back in the home district. The CBO found the problem to be as much about politics as it was about economics:

Large public depots are important local employers, and the allocation of work to the various depots and to the public and private sectors is a matter of Congressional interest. Thus, as a practical matter, the decision to close or reduce the size of a public depot must be made in a political as well as an economic forum. (Congressional Budget Office, 1995)

Further research into the risk of reliance on the private sector would be a necessary foundation for changes to Title 10. But even this cursory examination shows that the law's intent to shield the government from private industry during time of war is not realistic in today's environment of constant conflict and complex repair relationships between government and private industry.

The discussion now turns from the relevance of Title 10's organic core capability requirement to how the *existing* law is applied today, and how it might better be applied tomorrow in the context of combat aircraft operational flight programs. While the relevance of the law is worthy of discussion, its resolution is unlikely to occur in an

acceptable timeframe. Focusing the remainder of this paper on how to best operate within the confines of the law offers the greatest potential for a reasonable solution in a timely manner.

## IV. Current State of Affairs

### **Introduction: Today's Core Capability Designation Process**

Having accomplished a review of Title 10 and core logistics policy, the implementation of *current* law and policy is now described. The primary research method employed was the modeling of policy with sequence diagrams and functional models.

Deciding what systems should be maintained in support of an organic core maintenance capability is a process that is often misunderstood. In conversation, it is common for all parties involved to refer to a particular military *system* as “core” or “not core”. For example, the engines on F-15s are called “core” because F-15s play a role in our war/contingency scenarios and the government is therefore required to have the capability to repair them. This is not a proper interpretation.

Properly speaking, a military system should not receive the label “core.” The adjective “core” is used to describe a maintenance *capability*, not a system. Because the F-15 is a fighter aircraft that plays a role in U.S. war plans the government is required by Title 10 to maintain an organic capability to maintain F-15 engines. Thus, F-15 engine depot-level maintenance is designated as supporting the government's *capability* to maintain F-15 engines. And because F-15 engines are similar to fighter engines in general, F-15 engine maintenance supports DoDs organic capability to maintain similar engines under the “like-workload” principle earlier summarized.

The subtle difference between labeling a system “core” and labeling a capability “core” is evidenced in this 2000 US Army journal article:

It is difficult to define "core" and "core competencies" when discussing defense operations. For a commercial business, core competencies are the areas in which the company can achieve a definable preeminence and provide unique value for customers. For Government depots, core refers to the minimum depot size and composition (personnel, skills, and plant equipment) required to support the most intense combination of contingencies specified in the Defense Planning Guidance ... Each service establishes core programs using the guidance and methodology provided by the Office of the Secretary of Defense. Examples of core programs for the Army are the M1A1 Abrams tank, the Bradley fighting vehicles, and the Patriot missile launcher. So the Army, by law, must maintain the capability to conduct depot-level repairs on this equipment. (Withers, 2000).

The Title 10 requirement for an organic depot maintenance capability is implemented today in two logically sequential steps:

1. Identify core maintenance capabilities
2. Calculate the work capacity required to maintain these capabilities

### **Identifying Core Maintenance Capabilities**

The process of identifying core logistics capabilities begins with the Joint Chiefs of Staff (JCS) wartime scenarios. The JCS not only develops the scenarios but also identifies the capabilities<sup>1</sup>, in terms of numbers of specific weapon systems, required in a scenario. This identification of required military capabilities is the foundation of the core

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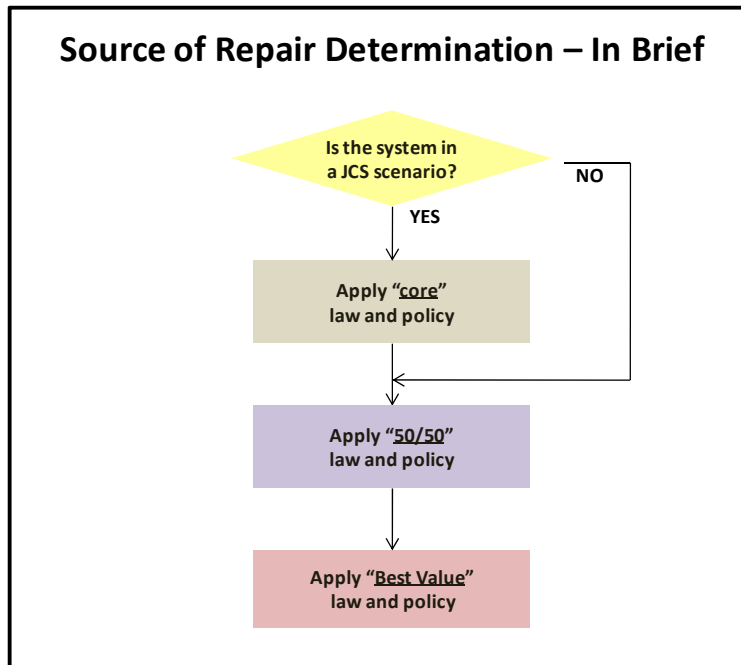
<sup>1</sup> The term “capability” is itself a potential source of confusion. In the context of JCS scenarios, “capability” refers to the military systems required to achieve particular effects. In contrast, DODI 4150.20 refers to a logistic “capability”, defined as the combination of skilled personnel, facilities and equipment, processes, and technology needed to perform a particular category of work, and that are necessary to maintain and repair the weapon systems and other military equipment needed to fulfill strategic and contingency plans.

determination process. Any system identified in the JCS scenarios by law must have an associated public sector depot maintenance capability. The inclusion of a weapon system in a JCS scenario is essentially a risk analysis and cost assessment for the sustainment of the system. The output of this analysis and assessment is always the establishment of a public sector depot maintenance capability.

The various service arms use the JCS list of critical weapon systems to identify the sub-systems within those weapon systems that will require government depot maintenance. This identification of *sub*-systems as requiring maintenance that satisfies organic core maintenance capability is currently a subjective process that is applied differently across services (AFMC/A4DC, 2009).

The method employed by the Air Force is to identify the capabilities required for a given weapon system to meet the JCS scenario and then aggregate up to the most logical system grouping. An example would be the requirement of a given weapon system to employ secure voice communications. Via aggregation, the entire communication system therefore requires a core logistics capability. By contrast, the Navy currently makes core determinations on a part-by-part basis (AFMC/A4DC, 2009).

DODI 4151.20 provides a flow chart for determining which systems require core logistics support and another for calculating direct labor hours (DLHs). Before examining this source of repair decision process in detail, Figure 13 provides a brief summary. The process begins with one question and then three differing categories of law and policy are applied.



**Figure 13. Source of repair decision - in brief**  
 (DoDI 4151.20 Depot Maintenance Core Capabilities Determination Process, 2007)

### **Calculating the Work Capacity Required to Maintain Core Capabilities**

Identifying what is a core capability is not sufficient, however, to ensure the capability exists. Like any system, the depot must maintain its ability to perform workload on mission essential systems. The capability to perform certain depot work must therefore be quantified. The DoD quantifies its core capability in terms of Direct Labor Hours (DLH). A minimum amount of work must occur in the public depot during peacetime to maintain the capability to perform required maintenance actions during time of war. The DLHs also aid in determining the size and number of facilities and the type and number of personnel.

DODI 4150.20 provides two detailed charts for use in calculating the required DLHs for a particular system and ultimately its source of repair. The content of these



two charts is combined in Figure 14, omitting minor processes such as the exclusion of systems excepted from the core process by the Secretary of Defense.

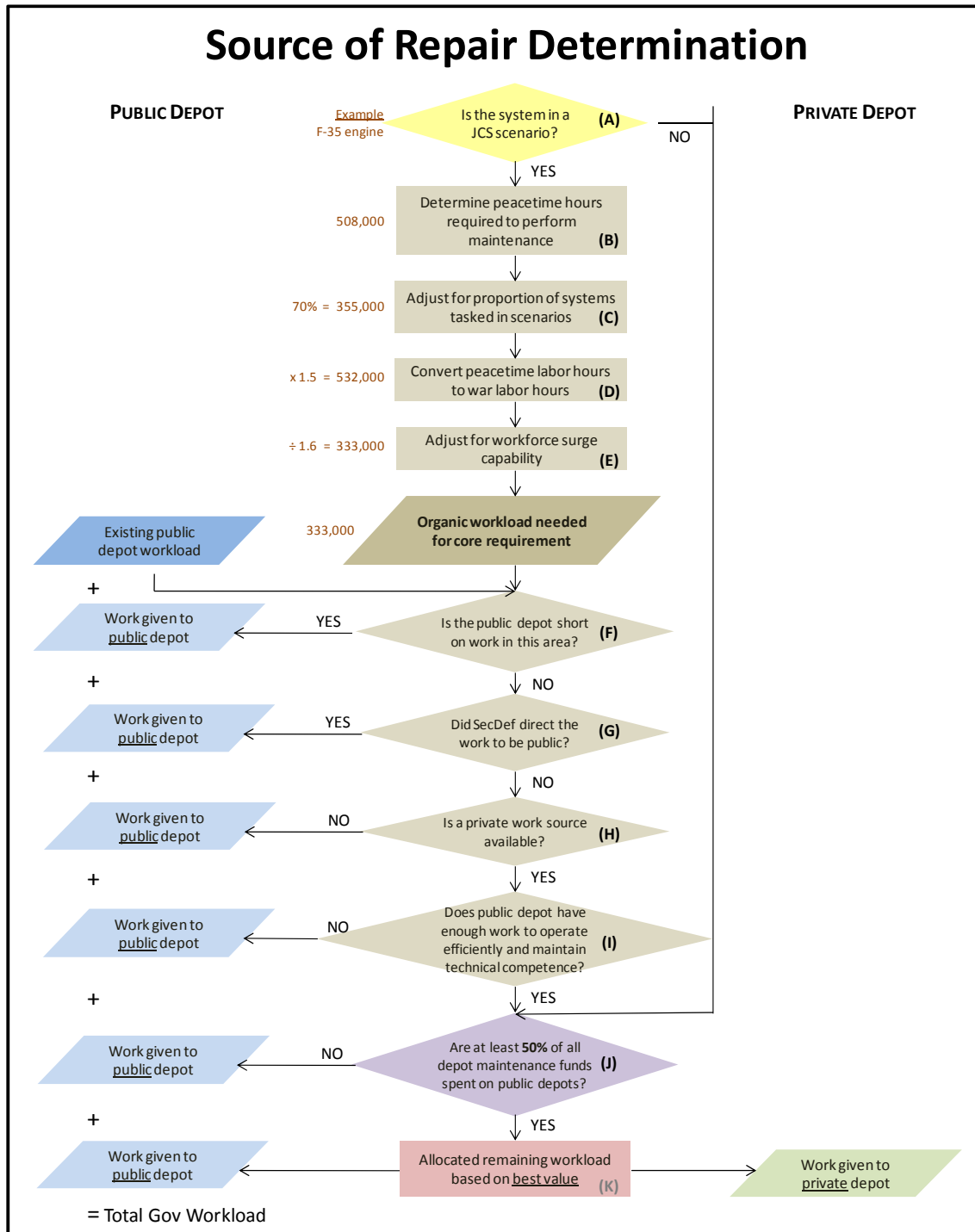


Figure 14. Source of repair determination (DODI 4151.20, 2007)

**Block A.** The top of the flow chart begins with a new system—the F-35 engine for example. After Initial Operational Capability (IOC) is declared, the F-35 will be a key player in JCS war plans and contingency scenarios and the government is therefore required to maintain the capability to maintain its various subsystems. The F-35 program office estimates that 508,000 labor hours will be required in peacetime to perform depot level maintenance on the F-35 engine (**Block B**). If the system in question does not play a role in JCS contingency scenarios, much of the decision tree is skipped, and only the “50/50” law is applied (discussed later).

**Block C.** Next, the labor hours are reduced by the proportion of F-35s that will be used in the scenarios. Because some of the jets are used for training and others are unavailable for other reasons, it is estimated that 70 percent of the F-35 fleet will be tasked in JCS scenarios. Seventy percent of 508,000 hours is 355,000 hours.

**Block D.** Because work on a specific subsystem will typically increase in preparation for a contingency or war, the peacetime hours are adjusted for maintenance surge at the beginning of an operation/contingency. Using historical data from other aircraft, the F-35 program office predicts that engine maintenance workload will increase by a factor of 1.5 during war. The 355,000 hours of maintenance now becomes 532,000 war time labor hours.

**Block E.** Next, the war time labor hours are adjusted for the ability of the government depot to work overtime during the wartime surge. The common “resource adjustment” multiplier in use today is 1.6. The 532,000 labor hours needed in war are divided by 1.6, resulting in 333,000 hours. In summary, the government depot must

perform 333,000 labor hours on F-35 engine maintenance during peace time in order to maintain the capability to perform all depot maintenance on 70 percent of all F-35 engines in time of war.

But this is not the end of the flowchart. The government depot may already expend many labor hours maintaining similar engines, or the work may be tasked out to the depot of a sister service. The lower half of the chart is used to consider several ways the core workload hours may be further adjusted.

**Block F.** Before the F-35 engine is considered, the government depot has been maintaining engines from other fighter aircraft. Workload data from this existing work now enters the picture. If the government depot does not have enough work to maintain the capability to repair fighter engines, some or all of the F-35 engine maintenance labor hours will be given to the government depot in support of the capability to repair fighter engines. If any labor hours remain after this step, the hours continue down the tree.

**Block G.** The Secretary of Defense may direct that maintenance on a system be performed by the government, in which case the remaining labor hours are allocated to the public depot.

**Block H.** Next, remaining hours are given to the public sector if no suitable depot maintenance capability exists in the private sector. If private depot maintenance capability exists, the remaining hours continue to the next block.

**Block I.** Title 10 Section 2464 requires the Secretary of Defense to allocate enough work to the government depots to maintain their “cost efficiency” and “technical

competence.” If the government depot is lacking in either area, labor hours are sent to public depots at this step.

**Block J.** If any labor hours remain at this point in the process, Section 2466 of Title 10 is applied. This law requires that a minimum of 50 percent of all *funds* spent for depot level maintenance of military systems be spent in the public sector. Continuing the F-35 example, if the Air Force is currently below the 50 percent floor across the board, F-35 engine labor hours would be allocated to the government depot.

**Block K.** Lastly, any remaining hours are competed between the public and private sectors for best value (cost-effectiveness).

After direct labor hours are allocated to a government depot, these hours are converted into dollar amounts that are used by the Planning, Programming, and Budgeting System (PPBS) to determine appropriate funding for the identified capabilities.

Note the dominant factor that drives depot labor hours to the public sector is Title 10’s motive of avoiding the risk of private sector work. Cost-effectiveness is not a primary concern until the end of the decision tree.

### **Functional Model of the Source of Repair Decision Process**

While the flow chart above provides a good overview of the decisions involved in the core capability determination process, it does not reveal several key factors that affect these decisions. This research team developed a functional model of the source of repair (SORAP) decision process which is now presented in the common IDEF0 (Integration

Definition Functional Model) format (Figure 15). Each block represents a function or activity. Inputs arrive from the left side of a block, outputs leave from the right, mechanisms are depicted along the bottom, and controls that guide the function or triggers that begin the activity are shown along the top of a block. The advantage of the IDEF0 model, in this case, is that it depicts the mechanisms for making decisions or accomplishing tasks. This is in contrast to the decision tree model which simply shows the flow of information and required decisions. Several additional observations can now be made about the source of repair decision process.



First, application of law and policy can generally be placed into three categories depicted by blocks A.3, A.4, and A.5 in Figure 15. Each of these categories divides labor hours or labor funds between the public and private sectors by different rules and for different motives.

<b>Rule</b>	<b>Motive</b>
1. <b>Core capability laws</b>	Protection from risk of private sustainment
2. <b>50/50 laws</b>	Several motivations in tension
3. <b>Best value / cost-effectiveness</b>	Value ( for work not covered by #1 and #2)

We now follow the process model and describe each function along the way. A variety of triggers can start the process. The most common trigger is the start of a new program/system that will require sustainment. Other triggers include a change in the war/contingency scenarios published by the Joint Chiefs of Staff or workloads at public depots falling below the minimum required to support a core maintenance capability.

Calculations required to determine if an organic capability shortfall exists are regularly accomplished and are represented in the model by function A.2. The primary mechanisms for function A.2 are the government depots, which generate labor reports that are used in identifying any capability shortfalls. The controls on this process are the laws and policies earlier summarized, which specify the frequency of reporting, the parties involved, and the content of the information reported. Title 10 provides the foundational requirement for reporting, and DOD and service-level instructions provide amplifying detail.

If the starting trigger is a new system such as the F-35 airframe, the first decision point is a simple determination of the system's role in JCS contingency scenarios.

Because the F-35 airframe does play a role in war plans, core policy is next applied (function A.3). Systems that are not included in war taskings, such as training systems, bypass the core laws and enter at function A.4 where 50/50 laws are applied.

The core policy function analyzes the system characteristics (F-35 airframe for example) and determines what portion of maintenance workload is required by Title 10 section 2464 to be performed by a government depot. Representatives from several organizations serve as mechanisms for this process. Mechanism organizations include USAF program offices and AFMC headquarters. At this point, a series of DoD and Air Force instructions guide the process by controlling how calculations are performed and when exceptions are authorized, based on Title 10.

Function A.4 then applies 50/50 laws and policies which require that a minimum of 50 percent of all depot maintenance funding be spent on organic work. Any labor hours not allocated to the government by this function are passed to block A.5.

The CBO and other interested parties have often argued for a greater role for the Best Value function (function A.5). The SORAP functional model reveals that core and 50/50 laws are the top priority. Cost-effectiveness does not become the primary workload allocation filter until well down the tree. Any workload that reaches this level in the process is competed between private and public sectors. Again, increasingly detailed policy controls this process.



In the end, all depot-level maintenance workload is allocated to either the public or private sectors. This workload can be split between the two sectors for a single system or subsystem—not all labor must be given to one or the other. Functions A.6 and A.7 represent the actual depot-level maintenance work of the public and private sectors respectively. The mechanisms for this work include the buildings, equipment, people, and money available to each depot.

Up to this point, funding source (“color of money”) has had no influence on the process. Functions A.6 and A.7 require the proper source of funding for budgeting purposes. As a rule, the only appropriations intended for the performance of maintenance are funds coded 3400 in the DoD Financial Management Regulation (DODI 7000.14-R). This category of funding is to be used for systems operations and maintenance, regardless of whether the work is done organically or by private contractor (DoD 7000.14-R Volume 2A Financial Management Regulation, 2008).

### **Functional Model Application: Aircraft OFPs**

Today, modification to a fielded OFP is normally treated as maintenance by AFMC and is therefore governed by the requirements of core capability laws. Given that OFP modification is classified as maintenance, when OFP workload for a given aircraft arrives at the last two blocks in the functional model the only funding mechanism appropriate is 3400 money (O&M funds). However, interviews with government depots and program offices revealed that sufficient 3400 coded funding is often not available for the workload required to update an OFP. Funding coded for R&D (3600) is sometimes

used instead (WR-ALC Interview, 2010). In the ideal situation, work associated with OFP modification would be designated either maintenance or development, and the type of funds appropriate to this work would be budgeted, and spent.

As this research will argue in following chapters, much OFP work is development and not maintenance, so it is logical to use 3600 money. But the functional model of the process reveals that if OFP work is considered maintenance, the only funding mechanism authorized is 3400 money. This reveals the problem created by categorizing OFP work as maintenance: maintenance laws are applied up front for depot workload allocation, while the funding process effectively recognizes the work as development.

#### **Functional Model Application: T-38 Engine (training system)**

Because training systems are not part of JCS contingency plans, such systems initially bypass core policy and enter at function A.4 (50/50 laws). However, because organic core capability is periodically assessed (function A.2), it could be that at some point the government lacks the capability to perform work on fighter-type engines due a workload shortfall in this area, triggering a re-evaluation of existing systems. If the T-38 engine was *similar* to combat coded fighter engines (in reality it is not), maintenance workload on the T-38 engine might be allocated to the government to help restore an organic capability in this area.

#### **Functional Model: Hardware and Software Contrasted**

If engine workload is given to the government, the remaining work is easily allocated to the private sector. For example, the government depot would be given 100 T-38 engines to sustain and the private depot would also be given 100 engines. But when

it comes to OFP modification, splitting workload is much more difficult. Unlike hardware which exists in many duplicate copies, a single OFP is loaded into all aircraft of a type. An OFP cannot be split like a group of engines. Portions of an OFP could be modified by different organizations, but the various portions of an OFP are highly coupled. In contrast, the work done on one aircraft engine does not affect the work done on another engine of the same type.

In this context, both the sequence model (Figure 14) and the functional model (Figure 15) portray a system that is well-suited to the allocation of maintenance workload for hardware, but not well-suited for software. While the challenge of dividing and allocating software modification workload persists, the current process can be modified to allow greater flexibility.

These improvements, along with further analysis of the differences between hardware and software, are examined in the following chapters.

### **Current State of Affairs: Summary**

The strain between the DoD's desire to perform cost effective depot maintenance and Congress's aversion to the alleged risks associated with excessive privatization of depot maintenance appears to have found a neutral point in the Title 10 core capability requirement and the 50/50 rule, allowing DoD some flexibility while retaining necessary capabilities in public sector. As recently as 2008, the GAO report *Issues and Options for Reporting on Military Depots* provided Congress with the following key issues to consider (Government Accountability Office, 2008).

- To what extent are 50/50 and core still relevant for assessing a required level of organic maintenance capability?
- What role are the depots to have in DoD weapons system support? Are they to be only used for legacy systems and as repairers of last resort when a contractor is not available, or are they to be a key source of repair for new and modified weapon systems?
- How does core depot maintenance fit into a DoD support scenario in light of DoD's preference for using performance-based logistics?
- If the maintenance depots are to remain relevant in the future, what actions are needed to ensure they are modernized and capable of performing maintenance on new systems?
- As it becomes more difficult to distinguish depot from intermediate maintenance and maintenance from other supportability functions, to what extent does it remain practicable to quantify a balance of public and private sector depot maintenance?
- Is it important for DoD to continue to define some level of core capability that it should perform using DoD military or civilian employees?

These questions are similar to questions independently generated by this research team and validated perceptions regarding the debate. The answers to these questions, which will undoubtedly shape the way the DoD performs depot maintenance in the future, are outside the scope of this research. This research is focused primarily on identifying ways to more effectively operate within constraints of current law.

## **V. What is Software Maintenance? Toward a Common Dictionary**

### **Software Sustainment Definitions Compared and Contrasted**

Review of existing policy, government reports, and trade journals revealed inconsistent and confusing use of key terms related to software sustainment. Lack of a common lexicon may be one reason for confusion and frustration with the core designation process.

Beyond the annoyance of confusing terms is the massive cost associated with this phase of the software lifecycle. Estimates report that sustainment accounts for 60-90 percent of the total lifecycle cost of a software product (Department of the Air Force Software Technology Support Center, 2003). Misinterpreting a definition could therefore cause expensive investment in an organic maintenance capability when in fact the work is mostly development. In this context, a set of common definitions is essential.

Therefore, this research team surveyed existing law, policy, regulations, guidebooks, and trade journals for definitions of the following terms:

- Sustainment
- Maintenance
- Development

Varying definitions for each term were then compared and contrasted, analyzing which documents contained definitions similar to other documents, and where definitions were missing. Following this analysis, a common lexicon of terms related to the development and maintenance of both hardware and software was developed for integration into policy documents. This improvement to policy documents would allow

more consistent use and understanding of terms and in turn more make more effective use of limited funding.

Analysis of the lexicon associated with depot level sustainment of hardware and software systems begins with identification of the key terms. Next, the team summarizes which sources agree and which sources differ in their definitions of these terms. Lastly, policy documents and Air Force instructions are identified which omit definitions where they would otherwise be useful in implementing depot maintenance policy.

### **Summary of Existing Definitions**

A common lexicon is critical to understanding, communicating, and implementing the depot maintenance requirements of Title 10 and associated DoD policy. Table 2 provides a quick summary of which documents address each of the key terms related to materiel and software sustainment, maintenance and development. The full complement of definitions can be found in Appendix A: Definitions. Of note, the term “development” was never adequately defined in any of the documents surveyed and is therefore not reflected in Table 2. In its place, however, policy documents do include related terms. The column labeled “Related Terms” contains all definitions that do not fit in the categories of sustainment and maintenance. In many cases, these definitions refer to development, modernization, or evolution of systems.

**Table 2. Mapping of publications to related definitions**

Document ▼	Term ►	Sustainment	Maintenance	Software Specific Terms	Related Terms
USC Title 10 Sec 2464			X		
DoD 5000.01					
DoD 5000.02		X			
DoD 7000.14-R		X	X		X
DODD 4151.18			X		
DoD 4151.18-H		X	X		
DODI 4151.20			X	X	
DODI 4151.21			X		
DODI 4151.22			X		
JP 1-02		X	X		
JP 3-0		X			
JP 4-0		X	X		
AFPD 63-1		X			X
AFI 63-101		X	X		X
AFI 63-107		X	X	X	X
AFI 63-128		X			
AFI 65-601			X	X	X
T.O. 00-25-4			X		X
GSAM Handbook		X		X	
IEEE 610.12-1990			X	X	X
IEEE 1219-1992				X	
NAVAIR Software Logistics Primer		X		X	
USAF Weapon System Software Mgt Guidebook				X	

As outlined previously, the next step was to map agreeing definitions between sources. While no instances of definitions blatantly disagreed between documents, a common lexicon could still help clarify policy decisions regarding software sustainment. Table 3 maps definitions between policy documents and reveals which definitions are common among multiple documents. Definitions are grouped by level in the policy hierarchy (i.e. DoD level versus Air Force level). Such groups are represented by a light grey box around the definitions.

This table, a fit-for-purpose architecture product, is loosely based on the DoD Architecture Framework (DODAF) SV-3 Systems-Systems Matrix (DoD Architecture Framework Version 2.0, 2009). In an SV-3, relationships among systems are mapped and highlighted. Table 3 substitutes systems for policy documents but depicts relationships similarly to an SV-3.



**Table 3. Definition mapping (depicts groupings of common definitions)**

	Title 10	DoD 5000.01	DoD 5000.02	DoD 7000.14-R	DoD 4151.18	DoD 4151.18-H	DODI 4151.20	DODI 4151.21	DODI 4151.22	JP 1-02	JP 3-0	JP 4-0	AFPD 63-1	AFI 63-101	AFI 63-107	AFI 63-128	AFI 65-601	T.O. 00-25-4	GSAM Handbook	IEEE 610.12-1990	IEEE 1219-1992	NAVAIR SLP	USAF WSSM
Title 10	M					M						M			M								
DoD 5000.01																							
DoD 5000.02			S																				
DoD 7000.14-R				SM R																			
DoD 4151.18					M												M						
DoD 4151.18-H	M					SM	M	M				M			M								
DODI 4151.20						M	MW	M															
DODI 4151.21						M	M	M															
DODI 4151.22									M														
JP 1-02										SM		S											
JP 3-0											S												
JP 4-0	M					M				S		SM			M								
AFPD 63-1													SR	SR	SR		S	R					
AFI 63-101													SR	SMR	SR			R					
AFI 63-107	M					M						M	SR	SR	SM WR			R					
AFI 63-128																S							
AFI 65-601					M								S				MW R						
T.O. 00-25-4													R	R	R			MR					
GSAM Handbook																			SW	W	W	W	
IEEE 610.12-1990																			W	MW R	W	W	
IEEE 1219-1992																			W	W	W	W	
NAVAIR SLP																			W	W	W	SW	
USAF WSSM																							W

S Sustainment Definition

W Software MX Definition

M Maintenance Definition

R Related Definition

This graphical representation of the current fragmented lexicon permits an important observation. The clumping of definitions at a given level (i.e. DoD-level policy) indicates a lack of lexicon continuity between hierarchical levels. For instance, there are no common definitions between Title 10 and the USAF Weapon System Software Manual. Likewise, there is a high degree of commonality among DoD policy documents but very little between DoD documents and Air Force documents. This lack of a common lexicon may explain much of the current frustration with the implementation of core logistics laws.

Additional patterns emerged after definitions were binned and compared. The first was a lack of consistency in defining “sustainment”. Very few documents formally defined sustainment and those that did had varied definitions. Those that did not define sustainment tended to identify activities that fall under the umbrella of sustainment rather than describe the sustainment effort itself. Secondly, definitions of “sustainment” are absent altogether at the bottom of the document hierarchy. The one exception to this is the Guidelines for Successful Acquisition and Management of Software Intensive Systems (GSAM) Handbook. The specifics of this handbook will be discussed later.

The next trend was the lack of an attempt to define software maintenance in the higher level documents. The first attempt to define software maintenance does not occur until AFI 63-101 *Acquisition and Sustainment Life Cycle Management*. At first glance this may seem logical, as the law and DoD documents are concerned with broad aspects of policy. But the detail with which they describe hardware maintenance proves otherwise. These documents use the term “software maintenance” yet fail to provide a

definition. For example, DoD 4151.18-H *Depot Maintenance Capacity and Utilization Measurement Handbook* describes “maintenance” as:

The processes of materiel maintenance or repair involving the overhaul, upgrading, rebuilding, testing, inspection, and reclamation (as necessary) of weapons systems, equipment end items, parts, components, assemblies, and subassemblies. (DoD 4151.18-H Depot Maintenance Capacity and Utilization Measurement Handbook, 2007)

Compare that detailed definition to this simple reference to software maintenance: “Depot maintenance also includes all aspects of software...” (DoD 4151.18-H Depot Maintenance Capacity and Utilization Measurement Handbook, 2007). The comparison indicates the DoD does not view software maintenance to be any different than hardware maintenance and therefore requires no further explanation.

Ambiguity in the use of terms is common at the lower end of the document hierarchy as well. The *Guidelines for Successful Acquisition and Management of Software Intensive Systems (GSAM)*, *NAVAIR Software Logistics Primer*, and the *USAF Weapon Systems Software Management Guidebook*, rarely use the term “maintenance” in the context of software. The GSAM uses the term “software *sustainment*” instead of “software maintenance”, yet its description of activities which constitute software sustainment are identical to those activities called software maintenance in other documents. Likewise, the NAVAIR primer refers to “software maintenance” but follows with a parenthetical “a.k.a. software sustainment” (Naval Air Systems Command, 2008).

Lastly, the USAF Weapons System Software Management Guidebook refers to “software *repair*” and then states that the processes required to repair software are very

similar to those used to develop it (Office of the Secretary of the Air Force for Acquisition, 2008). Taken as a whole, these three documents link software maintenance to software repair, software sustainment, and software development. However, they add confusion to the software repair versus sustainment discourse because they fail to define a common definition.

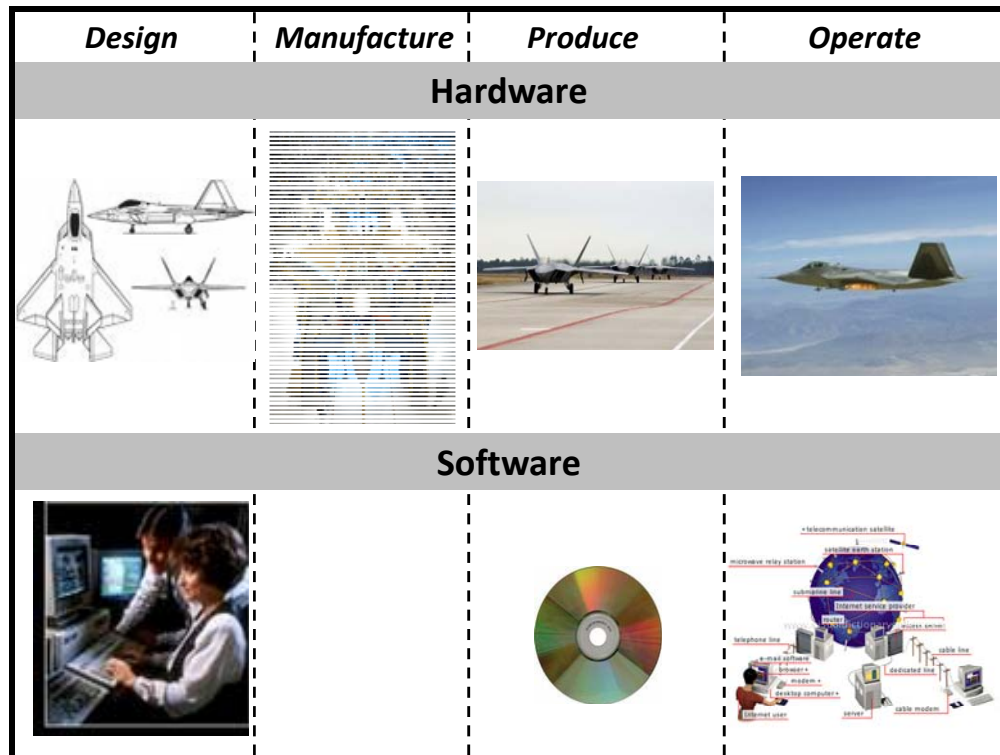
As previously stated, the DoD does not recognize a difference between software and hardware maintenance as evidenced in DoD 4150.18-H. Therefore, before a common dictionary is proposed, hardware and software maintenance is compared and contrasted in greater detail to demonstrate the differences.

### **Hardware and Software Maintenance Contrasted**

When the question arises, “What makes software different?”, the answer is varied and complex. The first answer is that software is invisible and intangible (Naval Air Systems Command, 2008). Software does not exist in the same manner as a piece of hardware. One can describe a piece of hardware through a set of drawings and specifications. Because software is essentially information-only (logical decision rules), it must be described by what it does rather than what it is. One cannot draw a picture of a piece of software. Instead, one describes the structure of the software logic (Crane, 2009). The processes for designing and maintaining software are therefore fundamentally different from those of hardware.

Second, software is designed but not manufactured (Crane, 2009). The outcome of the hardware design process is a set of blueprints or plans which are used to

manufacture products (often in great quantity) which are typically operated separately from each other. For example, two engines of the same design are in use in different squadrons. In contrast, the output of software design is a single software product that is operated by many users independently. Two identical engines are made of *different* chunks of matter. But two installations of the same OFP are made of the *same* information. Software is therefore designed, produced, and operated, but not manufactured. Figure 16 is a graphical depiction of this contrast.

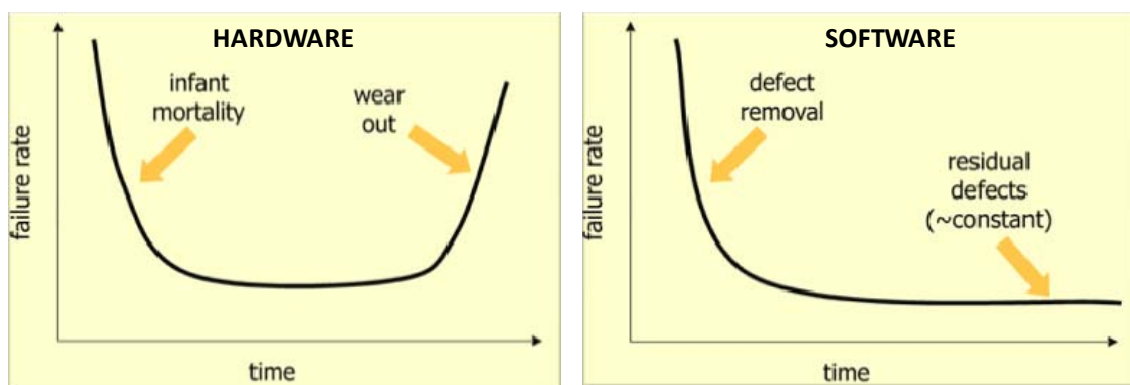


**Figure 16. Software and hardware differences (Hemmes, 2009)**

Another important difference between software and hardware is that software does not break or wear out (Crane, 2009). A piece of hardware wears out over time and

may break or fail during its lifecycle. When this occurs, one simply repairs the worn out part or replaces it with a spare part (Crane, 2009). This is not the case with software. Software does not break and could theoretically be operated indefinitely without wearing out. There are no spare parts for software (Crane, 2009). Software does, however, deteriorate with respect to its environment. The deterioration of software is primarily caused by a changing operating environment or due to unexpected combinations of inputs. Software deterioration is directly traceable to flaws in design (Crane, 2009).

Software deterioration is a common occurrence for many people. Something as innocuous as installing a new program can cause part or all of the system to function abnormally. Figure 17 graphically represent the differences between software and hardware failure rates as a function of time. The right plot specifically shows that software failures approach a near constant rate. In contrast, hardware (left plot) exhibits a constant failure rate for a period of time, but then begins to fail at an exponentially increasing rate.



**Figure 17. Software and hardware failure rates over time (Crane, 2009)**

Finally, software is not maintained in the classical sense of maintenance (Crane, 2009). Hardware maintenance consists of preventative maintenance (replacing consumables such as oil or replacing parts prior to failure) and corrective maintenance (repairing or replacing failed parts). Additionally, hardware maintenance simply returns the system to its designed functionality; it does not add new functionality or capability. This is not the case for software. “Software maintenance” as used in industry is much more broad, and the line between software maintenance and development is blurry at best. In fact, “it is reported that very few organizations adopt a separate process for [software] maintenance because they cannot make a distinction between software maintenance and development” (Sharma, 2004).

ISO/IEC 12207 *Software Lifecycle Processes* offers a guide to the various software lifecycle events. Figure 18 shows the processes involved within the lifecycle of a given piece of software. This document also recognizes an inherent link between software development and maintenance actions as development is a dependent process to maintenance. In his synopsis of ISO/IEC 12207, Raghu Singh of the Federal Aviation Administration states “Whenever a software product needs modifications, the development process is invoked to effect and complete the modification properly” (Singh, 1998).

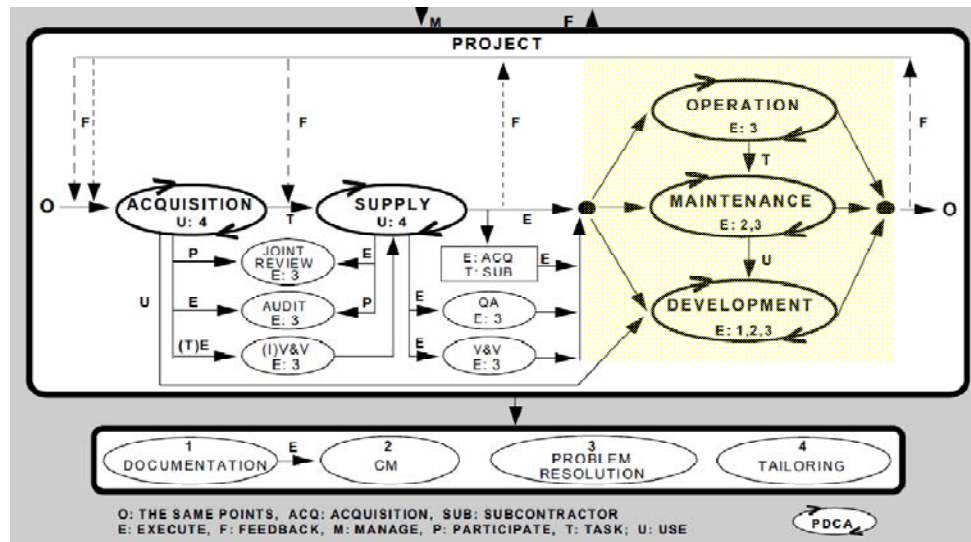


Figure 18. Software lifecycle process diagram (Singh, 1998)

The difference between software maintenance and hardware maintenance can also be understood intuitively. For example, suppose we were to accomplish aircraft landing gear maintenance by invoking hardware development, as is practiced in software maintenance. An aircraft lands hard and one of the gear struts is damaged. If the software maintenance paradigm were applied, the repair of the landing gear strut would involve the design of a new part. Now the example is reversed. After a period of time the same aircraft requires maintenance on its OFP. If software maintenance was performed with the hardware paradigm, maintenance personnel would simply install into the aircraft a fresh copy of the same OFP. Both of these scenarios seem absurd, but are useful in illustrating the fact that hardware maintenance and software maintenance are fundamentally different undertakings.

### Eight Laws of Software Evolution

The differences between software and hardware maintenance can be summed up in one term – Evolution. The maintenance of hardware is a static undertaking. A piece of



hardware should function the same before and after a maintenance action. In fact, the one thing most of the surveyed policy documents agreed upon was that maintenance primarily serves to return or retain an end item to serviceability (DoDI 4151.20 Depot Maintenance Core Capabilities Determination Process, 2007).

Software, on the other hand, will structurally look and possibly function differently before and after a maintenance action. The idea that software exhibits an evolutionary nature is not new. As early as the 1970s, studies were conducted on software systems to characterize their nature. As a result of these and subsequent studies, eight laws that govern the evolutionary nature of software have been defined. The eight laws of software evolution are (Lehman, 1997):

1. Continuing Change – A program that is used must be continually adapted or else it becomes progressively less satisfactory.
2. Increasing Complexity – As a program evolves it becomes increasingly more complex unless work is done to reduce it.
3. Self Regulation – The evolution process is self regulating with close to normal distribution of measures of products and process attributes.
4. Conservation of Organizational Stability – The average effective global activity rate on an evolving system is invariant over the product life time.
5. Conservation of Familiarity – During the active life of an evolving program, the content of successive releases is statistically invariant.
6. Continuing Growth – Functional content of a program must be continually increased to maintain user satisfaction over its lifetime.
7. Declining Quality – Programs will be perceived as of declining quality unless rigorously maintained and adapted to a changing operational environment.

8. Feedback System – Must be treated as multi-loop, multi-level feedback systems to be successfully modified or improved.

Laws 1, 2, 6, and 7 will be discussed because they are most relevant to the issue of classifying an OFP modification as either maintenance or development. The other four laws are no less important to understanding the nature of software evolution but are not germane to this discussion because they deal with the impact of software evolution on software modification processes and not with the software itself.

The first two laws are of particular interest. They state that software cannot remain unchanged without becoming unsatisfactory to the user. Arguably the user's desire for change is less about how the software functions than what functions it performs. In short, the desire for change is not driven by worn out software that can no longer perform its designed-to tasks, but rather users demand software that can continually provide new and better capabilities.

The concept of increasing complexity is particularly relevant when making a distinction between maintenance and development. Qualitatively, performing maintenance on an item should not increase its complexity. Software, however, naturally increases in complexity when modified. The increase in complexity is termed software entropy. Software entropy, or complexity, increases at a rate of one to two percent annually because of enhancements and bug fixes that occur on any software system (Jones, 2007). Therefore, any software effort that dramatically increases the entropy or complexity of the software would not likely be termed a maintenance effort but rather a developmental effort.

The sixth law of evolution states that software will become increasingly less acceptable over time even if it continues to function exactly as designed. This is more a statement about human nature than about software. When a software program is used extensively, all the functions it cannot perform are highlighted and dissatisfaction with the software increases. Additionally, as software ages it is invariably used in new and unintended ways which may highlight to the user functionality it lacks. An aircraft OFP is not immune to this law. The Air Force operational community actively engages in identifying new functionality for its OFPs.

The seventh law is important in understanding the nature of software maintenance. The first aspect of this law is the idea that a program is “perceived” to decline in quality. While the quality of the program does not change with time, the perception of the quality does change. When paired with hardware or other software programs for which it was not designed to interface, the software gives the appearance that it is “broken” by not operating as designed. The second aspect of this law is the concept of a “changing operational environment”. Taken out of context this can change the scope and meaning of this law. The operational environment an aircraft operates in could change from a benign air-to-air threat (such as OPERATION IRAQI FREEDOM) to an intense air-to-air threat (such as MiG alley in the Korean War). That environment, however, is outside the boundary of the software environment. Typically, the software environment boundary is drawn around the actual hardware which runs the software. Everything inside that boundary is the operational environment and everything outside that boundary is the external environment. Changes to the external environment do not

necessarily change the operating environment and therefore are outside the purview of this law.

### **In-Depth Examination of Software Maintenance**

These basic laws have been translated into concrete definitions for the maintenance of software by various organizations such as The Institute of Electrical and Electronics Engineers (IEEE). The definitions are discussed below and are summarized in Appendix A. Software engineering, however, is a discipline in its infancy when compared to hardware-related disciplines. As such, the terms used to describe the discipline are rapidly evolving in both number and meaning. In some instances, terminology does not exist to properly describe software engineering activities while in other instances the terminology is sufficiently vague (or rooted in the world of hardware) that multiple meanings emerge depending on what organization or individual within an organization is using the term (AFMC/A4DC, 2009). The Institute of Electrical and Electronics Engineers (IEEE) has developed a standard glossary of software engineering terminology which is described in IEEE Std 610.12-1990.

In terms of software maintenance specifically, a standard terminology is particularly necessary. In a world of well-defined and understood maintenance practices for hardware, it is easy to assume that software maintenance can be handled under the same paradigm. IEEE Std 1219-1992 *IEEE Standard for Software Maintenance* provides the baseline for understanding software maintenance.

Software maintenance is broadly defined as, "... the totality of activities required to provide cost-effective support to a software system" (Canfora & Cimitile, 2000).

IEEE Std 610.12-1990 further defines software maintenance as, “The process of modifying a software system or component after delivery to correct faults, improve performance or other attributes, or adapt to a changed environment” (Institute of Electrical and Electronics Engineers, 1990). It alternatively defines the maintenance of hardware as, “The process of retaining a hardware system or component in, or restoring it to, a state in which it can perform its required functions” (Institute of Electrical and Electronics Engineers, 1990).

The IEEE definition views the maintenance of hardware and software to be separate and distinct undertakings. The definitions indicate that software maintenance is fundamentally different than hardware maintenance. As the word maintenance would imply, hardware maintenance is focused on keeping a piece of hardware in good working order or returning a broken piece of hardware to that same working order. Central to this notion is that good working order does not change over time; the functionality of the good working order state never changes. In contrast, software maintenance includes not only correcting faults to a good working state but also improving and adapting performance. These two notions set software maintenance apart from hardware maintenance.

**Adaptive maintenance.** IEEE further divides software maintenance into the categories of adaptive, corrective, and perfective maintenance. Adaptive maintenance is defined by IEEE 610-12.1990 as, “Software maintenance performed to make a computer program usable in a changed environment” (Institute of Electrical and Electronics Engineers, 1990). This definition is further refined by IEEE 1219-1992 as, “Modification

of a software product performed after delivery to keep a computer program useable in a changed or changing environment” (Institute of Electrical and Electronics Engineers, 1992). As previously stated, the term “environment” refers to the software environment and not the environment external to the system. An example of adaptive maintenance could be updating a word processing program in response to an upgrade of the operating system from Windows Vista to Windows 7.

**Corrective maintenance** is defined by IEEE 610-12.1990 as, “Maintenance performed to correct faults in hardware or software” (Institute of Electrical and Electronics Engineers, 1990). Again, this definition is refined by IEEE 1219-1992 as, “Reactive modification of a software product performed after delivery to correct discovered faults” (Institute of Electrical and Electronics Engineers, 1992). The definition of corrective maintenance is one that fits most closely with the traditional view of maintenance which identifies and rectifies faults to return a system to good working order. An example of corrective maintenance is the issuance of a software patch that fixes a bug which causes a program to crash.

**Perfective maintenance** is defined by IEEE 610-12.1990 as, “Software maintenance performed to improve the performance, maintainability, or other attributes of a computer program” (Institute of Electrical and Electronics Engineers, 1990). IEEE 1219-192 refines this definition to, “Modification of a software product after delivery to improve performance or maintainability” (Institute of Electrical and Electronics Engineers, 1992). The ambiguity that exists in this definition leaves room to improperly identify the system boundary considering “improving and adapting performance”. The

definition refers specifically to the performance of the software, and not to the functions the software performs. For example, modifying software to perform a given calculation more quickly would be improved software performance. Modifying software to perform a calculation it could not previously perform is not improving software performance, but would be adding additional system functionality. Figure 19 summarizes these three types of software maintenance and provides a typical example of each.

Software Maintenance Categories (IEEE)	
Software Maint. Type	Example
Corrective	Correct bugs / errors
Perfective	Faster cleaner code
Adaptive	Adapt existing code to new processor environment

**Figure 19. Types of software maintenance according to IEEE**

In his 2007 Crosstalk (The Journal of Defense Software Engineering) article, Capers Jones offers 23 forms of software modifications that fall within the purview of software maintenance and are listed in Table 4. He argues the two most common meanings are defect repairs and enhancements. Repairs and enhancements typically are accomplished via different processes and sources of funding. However, funding sources are combined by many software companies. He cautions against the practice of

aggregation because distinguishing maintenance efforts from enhancement efforts becomes difficult (Jones, 2007).

**Table 4. Kinds of software work performed under the generic term “maintenance” (Jones, 2007).**

<b>Software Work Performed Under the Generic Term “Maintenance”</b>	
1. Major enhancements	(new features of > 20 function points).
2. Minor enhancements	(new features of < 5 function points).
3. Maintenance	(repairing defects for good will).
4. Warranty repairs	(repairing defects under formal contract).
5. Customer support	(responding to client phone calls or problem reports).
6. Error-prone module removal	(eliminating very troublesome code segments)
7. Mandatory changes	(required or statutory changes).
8. Complexity or structural analysis	(charting control flow plus complexity metrics ).
9. Code restructuring	(reducing cyclomatic and essential complexity).
10. Optimization	(increasing performance or throughput).
11. Migration	(moving software from one platform to another).
12. Conversion	(changing the interface or file structure).
13. Reverse engineering	(extracting latent design information from code).
14. Reengineering	(transforming legacy application to modern forms).
15. Dead code removal	(removing segments no longer utilized).
16. Dormant application elimination	(archiving unused software).
17. Nationalization	(modifying software for international use).
18. Mass updates such as the Euro or Year 2000 (Y2K) repairs.	
19. Refactoring, or reprogramming, applications to improve clarity.	
20. Retirement	(withdrawing an application from active service).
21. Field service	(sending maintenance members to client locations).
22. Reporting bugs or defects to software vendors.	
23. Installing updates received from software vendors.	



The Naval Air Systems Command (NAVAIR) offers a more generalized list of software modifications. They assert the existence of eight drivers of change to a fielded software systems (Naval Air Systems Command, 2008):

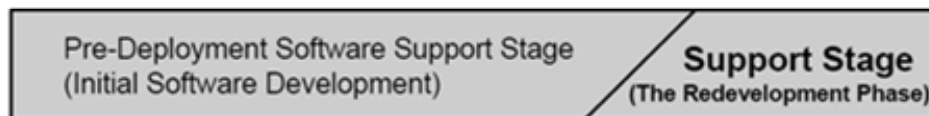
- |                       |                         |
|-----------------------|-------------------------|
| 1. Defect corrections | 5. Interoperability     |
| 2. Threats            | 6. Hardware Changes     |
| 3. Policy or Doctrine | 7. Technology Insertion |
| 4. Safety             | 8. Functional Changes   |

From these drivers of change they derive four basic sustainment activities the DoD performs on its systems (Naval Air Systems Command, 2008):

1. Improving performance and other attributes
2. Adapting software to new hardware
3. Adding features and functions to the software to respond to new user requirements and/or threat environments
4. Improve efficiency and reliability

These activities are labeled software sustainment activities, and the same Navy document equates “sustainment” with “maintenance”. But NAVAIR then describes the software life cycle as one of development from beginning to end (Figure 20), separating software support activities into either initial software development or software redevelopment (Naval Air Systems Command, 2008).

### **Software Support Activities and the Acquisition Life Cycle**



**Figure 20. NAVAIR view of the software lifecycle (Naval Air Systems Command, 2008).**

In summary, software maintenance is fundamentally different than hardware maintenance. Most software maintenance efforts improve the software, while hardware maintenance is generally intended to return the hardware to its original functionality. Unfortunately, most policy documents do not contain clear and comprehensive dictionaries of key terms. The definitions that do exist generally agree within a single level of policy hierarchy (among DoD policy documents for example), but there is little continuity between definitions across all levels of policy and guidance documents.

IEEE's categories of software maintenance are helpful and in use by HQ AFMC, but the definition of "adaptive software maintenance" is easily broadened to wrongly include significant performance improvements. While NAVAIR's software maintenance categories are generally aligned with those of IEEE, confusion of terms exists. Post-fielding, NAVAIR uses the terms "software maintenance", "software sustainment", and "software development" to describe the same software modification work. Clear definitions are needed for all branches of the DoD and at all levels of authority, from Title 10 to DoD and Air Force policy to low-level guidebooks.

### **Unique Characteristics of OFPs Among Software Types**

The definitions for software maintenance from IEEE generally follow the eight laws of software evolution. They tend to capture the essence of the activities associated with maintaining the long-term viability of a software program. When applied by those in the various software disciplines they are well understood. Where they fall short is the intersection where software and hardware meet. As highlighted by NAVAIR, not every

software effort is strictly maintenance; there are other aspects of software modification that must be accounted for.

Figure 21 shows a spectrum of software and hardware products from Information Technology (IT) software to hardware. IT software is used in the retrieval, storage, processing, and transmission of information. The characteristics of OFP software place it somewhere between IT software and hardware. The major distinction between OFP and IT software is the relationship between the hardware environment and the software. In IT software is the relationship between the hardware environment and the software. In general, private industry develops hardware to run IT software programs. But for an OFP the order is reversed: software is designed to support hardware. In short, the output of an IT system is information which is then used by a wide variety of external systems. In contrast, while the output of an OFP is also information, this information is used for a single purpose by a single external system: the employment of weapons (hardware) by an aircraft.

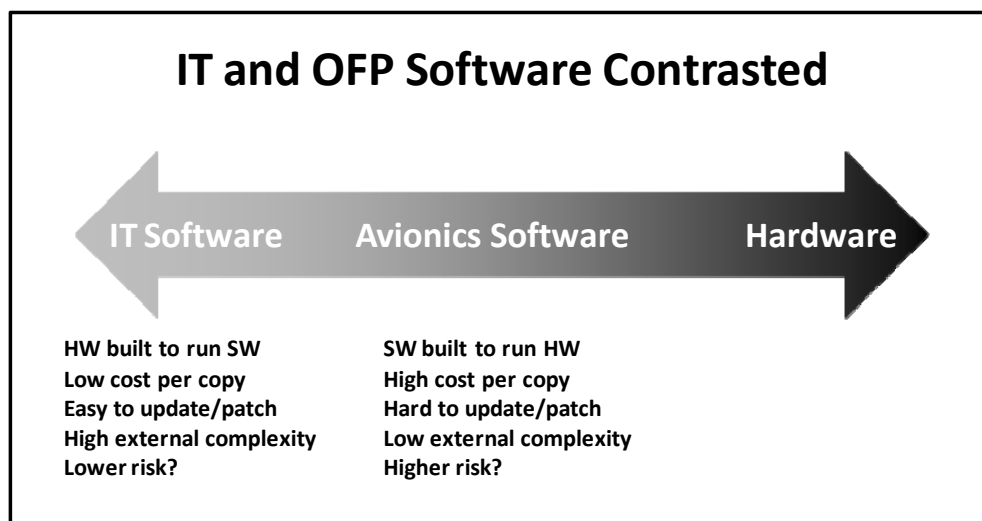


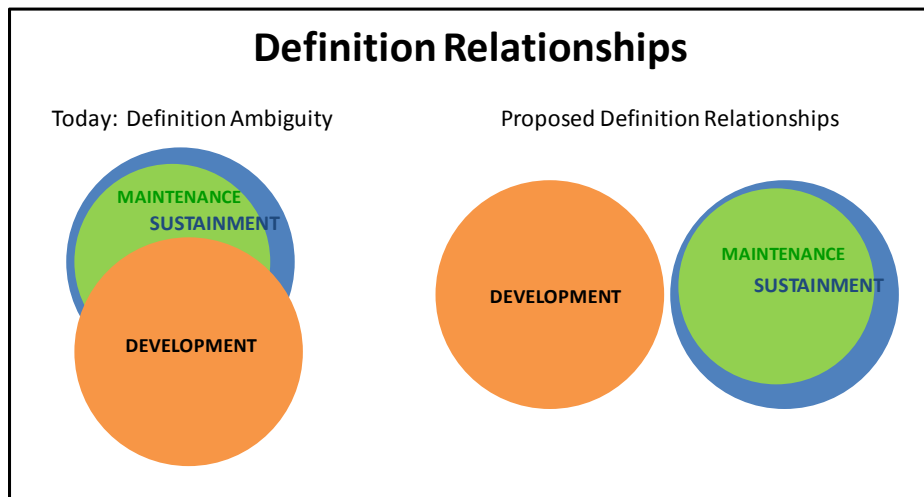
Figure 21. IT and OFP software contrasted

Secondly, the maintenance of IT software typically involves short timelines and generally follows the IEEE definitions of software maintenance, while a modified OFP release takes several years to develop and includes significant new capability. For example, Microsoft may perform maintenance on the Windows operating system to adapt to new processors or to fix security vulnerabilities. The per-copy cost of Windows is low, and these maintenance releases are made quickly when compared to an OFP release cycle. In contrast, major OFP releases post-IOC are often massive efforts performed at great expense with extensive flight testing that improve performance and add new capabilities. When viewed in this context, it is understandable that OFP maintenance is a confusing concept. An OFP is software, but it has unique characteristics which make the application of existing IT software maintenance definitions difficult.

As an example of how confusing definitions impact the implementation of policy, the GAO report *Actions Need to Identify and Establish Core Capabilities at Military Depots* found that the Navy and Marine Corps did not include software maintenance as a core capability because they did not “consider software maintenance as maintenance in the usual sense of returning an item back to its original condition” (Government Accountability Office, 2009). Rather than address the source of confusion, the OSD responded that the biennial core guidance defined depot maintenance to include all aspects of software maintenance. The implication is that all post-deployment software efforts are subject to Title 10 depot maintenance requirements. As of this writing, the Navy is working to incorporate software maintenance as a core capability (AFMC/A4DC, 2009).

## **Proposed Definitions**

The first step in effectively communicating the source of repair decision making process (much less improving it) is to establish a common lexicon. While existing definitions are inconsistent and overlapping, we propose clear lines and grouping of similar terms, as depicted in Figure 22.



**Figure 22. Definition relationships**

In common operational use, the words “sustainment” and “maintenance” are synonymous, and refer to keeping a previously established level or quality (JP 1-02 Department of Defense Dictionary of Military and Related Terms, 2007). The use of these words in policy documents reflects their similarity, and formal distinctions between the two terms were minimal. Maintenance is included in sustainment, along with supply chain management and other support activities. But the terms are synonymous in terms of work done to repair, or overhaul military systems. It is therefore proposed that these two terms be formally defined as synonymous and together distinguished from “development”.

The authors propose the following definitions:

**Hardware Maintenance/Sustainment:**

*Material repair, overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment which restores or retains the originally designed functionality.*

**Software Maintenance/Sustainment:**

*Reactive modification of a software product performed after delivery to correct discovered faults, keep a computer program usable in a changed software environment or improve its processing performance or maintainability.*

**Software Development:**

*Modification of software that adds new capabilities, changes the functional baseline, significantly increases complexity, or responds to significant new user requirements.*

The advantages of these new definitions are:

1. They clearly distinguish between software and hardware maintenance. This allows policy to be clear in its intent and application toward any of the defined work types.
2. They separate modernization efforts from maintenance efforts. As indicated in Figure 15, current processes do not allow for funding other than operations and maintenance. By providing a stand-alone definition of software modernization, it will now be possible for post-deployment software efforts to use appropriate sources of funding.
3. The definition of software modernization uses specific terminology which allows a more systematic identification of work type.

The disadvantages of the new definitions are:

1. Separating software development from software maintenance forces the categorization of an overall software effort as either maintenance or development, which may be difficult as aspects of both development and maintenance may be present. A model is proposed in the next chapter as an aid in making this determination.
2. The ambiguity that exists with current definitions allows for flexibility in their application to law, policy, and funding.

The need for accurate definitions to describe work that is currently accomplished on combat aircraft OFPs is urgent. As evidenced by NAVAIR's recent move to include software modification as a core logistics capability, a simple misunderstanding of definitions could result in large expenditures on unplanned organic maintenance infrastructure. Separating maintenance from development, however, is not without its challenges. Challenges such as securing the appropriate funding and overcoming the inertia of the status quo might impede the adoption of new definitions. Those challenges are outside the scope of this study, however, and the next chapter proposes a means for categorizing OFP modification as either maintenance or development.

## **VI. OFP Sustainment: Maintenance or Development?**

The final chapter will conclude with a recommendation about who should perform OFP updates: the government, the private sector, or a mix. But first, it must be determined if OFP development falls under the umbrella of Title 10's requirement for a government depot maintenance capability. If it can be shown that some OFP modification is not a maintenance or repair action, then Title 10 does not apply and the DoD is free to select a work source for OFPs based on other factors such as cost-effectiveness. We will first examine examples of hardware and software maintenance, then consider software in particular.

As previously stated, AFMC currently separates software maintenance into four categories adopted from industry: corrective, perfective, preventative, and adaptive (AFMC/A4DC, 2009). Figure 23 provides examples of software work in each of these categories as the authors envision them. The last column contains hardware analogies for each of these categories, although hardware maintenance is not formally categorized in this manner.



### Categories of Software Work In Use by AFMC

	MAINTENANCE		DEVELOPMENT	
Work Type	Software	Hardware Analogy	Software	Hardware Analogy
Corrective	• Correct bugs / errors	• Crack repair	N/A	• New wings for A-10
Preventive	N/A	• Inspections, stiffeners	N/A	N/A
Perfective (improving)	• Faster cleaner code	• Improve maintainability via more access panels	• New capability	• New engines for greater speed
Adaptive	• Adapt existing code to new processor environment	N/A	• OFP updated to support new weapon for new threat env.	• New jet (F-22) for changed threat env.

**Figure 23. Categories of software work in use by AFMC**

Several observations about the line between software maintenance and development are now made using Figure 23. Corrective modifications are normally maintenance. Software may be corrected to fix bugs which prevent the software from performing an intended function. Likewise, a hardware system undergoes corrective maintenance to repair a cracked or worn component. However, there exists corrective action which is development. For example, as the A-10 ages, its wings developed cracks requiring the design of an entirely new wing built by a third party. Preventive work is almost always a *hardware* maintenance action because software does not wear out.

The last two categories, perfective and adaptive, are the most difficult to divide into maintenance and development. If perfective maintenance improves software or hardware, then any work that adds new capability could be construed as perfective *maintenance*. However, a line must be drawn between perfecting the software or

hardware for its current function and improving the software or hardware by adding significant new capability. For example, modifying an OFP to achieve the same functionality more efficiently by writing cleaner code would appropriately be called a maintenance action. Likewise, minor changes to hardware that improve the maintainability could be considered maintenance. But modifying an OFP to add significant new capability as a result of new user requirements is more appropriately labeled “development”, even though the OFP is being perfected or improved in a broad sense.

Adaptive maintenance is likewise difficult to categorize. The key is to identify the boundary of the environment to which an entity is adapted. If software must be operated on a new chip, maintenance action is performed because of this change in the hardware that runs the software. But if our enemies design a new way of building hardened bunkers, the modification of an OFP to support a new bunker-busting weapon is development. Because the *threat environment* changed, some might argue that this OFP modification is “adaptive”. But taken to its logical conclusion, this reasoning would make the development of every military system a “maintenance” action because the United States is merely adapting to the changed threat environment by creating new weapons. So the environment boundary must be drawn closer to apply the label “adaptive maintenance”.

### **Characterizing OFP Modifications: Qualitative Model**

Now that a definition of “software maintenance” has been established, the focus is narrowed to aircraft OFPs. OFP maintenance is contrasted with OFP development. As stated previously, if OFP modification is determined to be development and not maintenance, then the organic capability requirements of Title 10 do not apply.

Currently, all OFP modification not accompanied by a hardware change, and much OFP work associated with hardware change is classified as maintenance by HQ AFMC (AFMC/A4DC, 2009). Today, the SORAP decision accomplished prior to IOC normally states that OFP work on combat aircraft supports a core capability, and this classification may remain for the life of the system. An alternative to this current practice would be to make early assessment of whether OFP modification is development or maintenance for each major release. To this end, a model for aiding in this decision is proposed. By using a model, OFP modification work can be properly classified and accurately considered under the provisions of Title 10 and DoD policy.

Key to developing a process to identify the nature of an OFP modification is the characteristics of software development versus software maintenance. Those characteristics can then be used to evaluate software work and properly categorize it. OFP characteristics useful in performing this examination are listed in Figure 24. These characteristics were identified by analysis of current definitions and policy, the input of interviewed depot engineers, and the experience of the authors in operational use of various OFPs.

AFMC/A4D currently classifies software modification as development only if it is accompanied by a hardware modification (AFMC/A4DC, 2009). This paradigm, that hardware changes drive software development, causes some software development that is not accompanied by new hardware to be mis-classified as maintenance.

For example, with no change to hardware, the F-15 radar OFP could be modified to allow significant new capability such as target identification modes, increased number of tracked targets, or new data link modes to existing weapons. Such work would result in a significant increase in OFP complexity and yet not be associated with a hardware change. While the second law of software evolution states that there will be a natural increase in complexity with changes to software, it is not referring to significantly increased complexity that comes from a development effort to add new capability.

Finally, OFP modification work can be categorized as maintenance or development based on the baseline which is affected. This idea was proposed by Lt Col Joe Jarzombek's in his 1997 Crosstalk Article:

We can formally clarify the differences among development, modification, and maintenance activities by delineating software support activities among functional, allocated, and product baselines. For example, to fix software bugs to comply with existing baselines or specifications could be considered maintenance (although many would argue that code changes are changes to product baselines, and as such are modification rather than maintenance activities). To change software design or interfaces among modules is clearly a modification activity, since it impacts product or allocated baselines. To add new capabilities outside the scope of the existing functional baselines would be development. (Jarzombek, 1997)

According to a 2009 briefing by the 830<sup>th</sup> Aircraft Sustainment Group at Robins Air Force Base, “the F-15 is ...currently undergoing the most complex and lethal upgrades in its history” (Reed, 2010). This hardly fits the paradigm envisioned by Title 10 core laws whereby a system is in high flux during development but then generally reaches steady state after it is in use operationally, and requires only maintenance. The F-15, now over 30 years old, is an example of an old jet gaining significant new capabilities. And the F-15’s OFP is being modified to integrate the information flowing from and to these new systems.

Additional characteristics that operational experience has shown to differentiate software maintenance from development are:

- Amount of flight testing required
- Amount of training required for the operator of the new OFP
- Rate at which modified OFPs are released to the field

The testing benchmark is important because a large test effort is a strong indicator that something is undergoing development. Modification to an OFP requiring 568 test sorties is not a maintenance effort. Yet such was the case with the F-15C Suite 5 OFP (Gatlin, Spain, Stands, & White, 2007). Additionally, new technical orders and/or new operator training and certification on an OFP are typically required only when new functionality is added to the system—another indicator of development

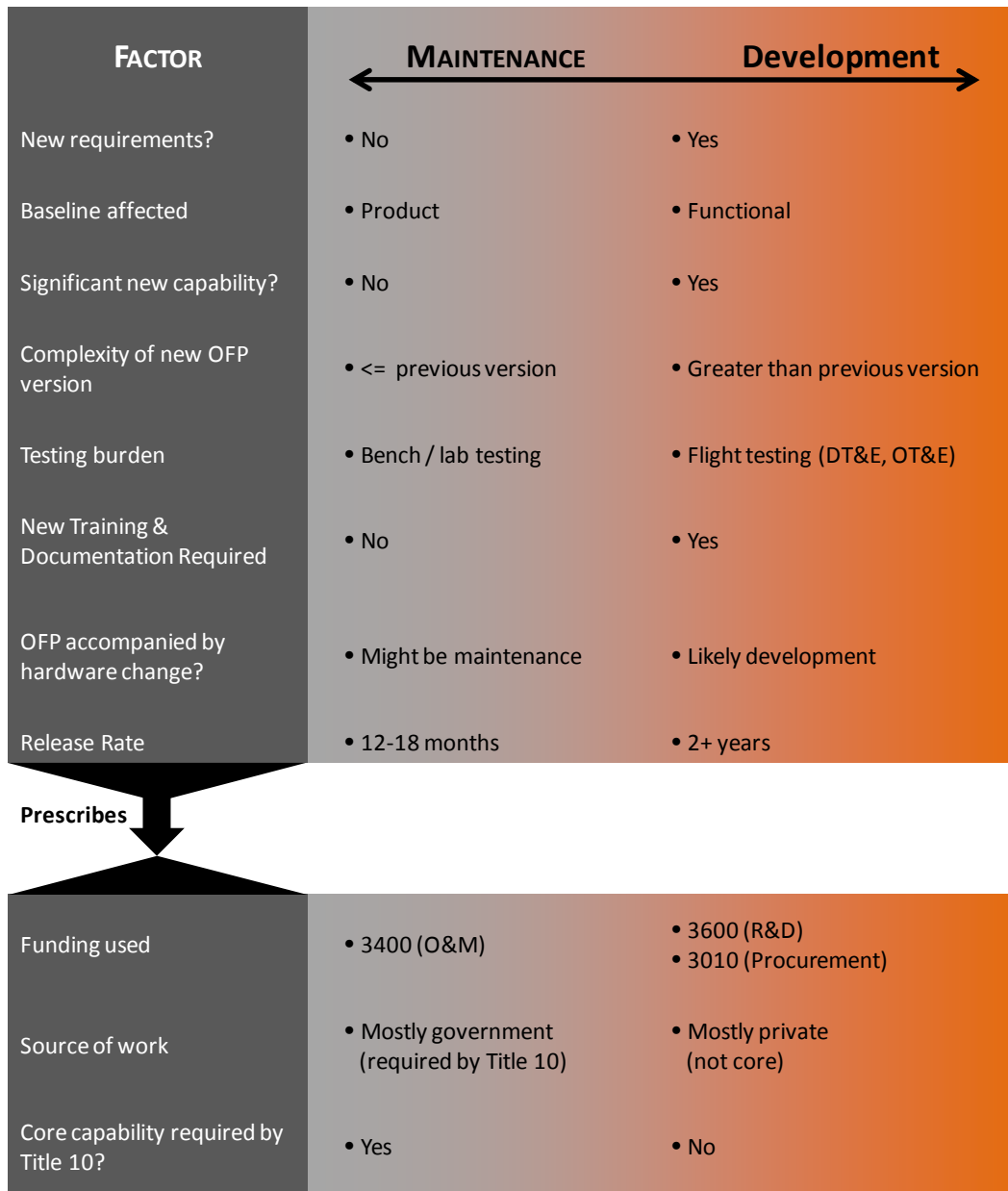
Finally, a rapid release rate is indicative of maintenance action while significant time between releases indicates that more than bug fixes are occurring.

The authors propose a qualitative model (Figure 24) that characterizes an OFP by the following eight basic characteristics:

1. Amount of new requirements incorporated
2. Baseline affected by the modification
3. Amount of new capabilities incorporated
4. Net change in complexity
5. Testing required to field the OFP
6. Level of training and documentation required to operate the OFP
7. Whether the OFP modification is accompanying a hardware change
8. Time interval between the current OFP release and the previous release

Figure 24 lists each of the eight characteristics and then qualitatively defines what makes that characteristic of the OFP modification either maintenance or development.

## OFP Modification: Maintenance or Development?



**Figure 24. Qualitative model for OFP work classification**

### Qualitative Model Applied to F-15C OFP Suite 4

The research team evaluated the characteristics of the F-15C's Suite 4 OFP with the previously presented qualitative model. As shown in Figure 25, Suite 4 flagged all of the qualitative indicators of development work even though 25 years had passed since IOC. Yet, the work was categorized "core" by AFMC and designated a maintenance effort.

### F-15C Suite 4 OFP (25 years after IOC)

FACTOR	← MAINTENANCE      Development →	
New requirements?		<ul style="list-style-type: none"><li>• Support AIM-120 C5</li><li>• Support AIM-9X</li><li>• Helmet mounted display</li><li>• New radar</li></ul>
Baseline affected		<ul style="list-style-type: none"><li>• Functional</li></ul>
Significant new capability?		<ul style="list-style-type: none"><li>• New ID modes</li><li>• New weapons</li><li>• New pilot displays</li></ul>
Complexity of new OFP version		<ul style="list-style-type: none"><li>• &gt; previous version</li></ul>
Testing burden		<ul style="list-style-type: none"><li>• 325 flights (DT &amp; OT)</li></ul>
New Training & Documentation Required		<ul style="list-style-type: none"><li>• New operator's manual</li><li>• New simulator software</li></ul>
OFP accompanied by hardware change?		<ul style="list-style-type: none"><li>• New radar</li><li>• New weapons</li></ul>
Release Rate		<ul style="list-style-type: none"><li>• 2+ years</li></ul>
Were core laws applied?	Yes, but model indicates →	<b>DEVELOPMENT</b>

Figure 25. F-15C Suite 4 qualitative assessment



The attributes in the model (Figure 24) provide the means for *qualitatively* evaluating an OFP to determine whether a software effort is most likely categorized as maintenance or development. The main disadvantage of the qualitative model is that it is subject to interpretation. Subjective assessments are not ideal for categorizing a software effort that has attributes of *both* maintenance and development. A quantitative means for assessing an OFP is therefore desirable.

### **Quantitative OFP Assessment Tool (QuOAT)**

The QuOAT is a tool for converting qualitative assessments into quantitative measures. This is accomplished by weighting eight OFP attributes determined to be indicators of software modification work classification, as previously discussed.

The attributes in the QuOAT model are weighted within an attribute category but not across attribute categories. Each attribute receives equal weighting in the overall assessment. No single category receives more weight compared to other categories. This approach was chosen because no attribute was found to contribute to the classification of OFP work more than any other attribute.

Although the QuOAT's output is a quantitative value representing the degree to which an OFP modification is either development or maintenance, the model is intended as an aide in source of repair decisions and not the primary decision making tool.

The attribute weights in the QuOAT ranges from 0 to 100. A "0" score in any attribute category strongly indicates that the OFP modification work has characteristics of maintenance. Conversely, a 100 score in any attribute category is a strong indicator that

the OFP attribute is related to a development effort. The other two weighting options are 45 and 55 and are intentionally close to the midpoint value of 50. Values in this range indicate a weak discriminator of work classification. Using the 45 and 55 weighting options eliminates over-emphasis of attributes that do not clearly indicate OFP work as being either maintenance or development. The 0-100 scale was chosen to provide a large gap between an attribute category scored as maintenance and one scored as development. A 0-10 weighting scale provides an identical outcome but makes the classification of an OFP less obvious.

The implementation of the QuOAT is a four step process with Table 5 as a guide:

1. Make a qualitative assessment of the OFP modification work within each of the eight attribute categories based on the descriptive statements in Table 5.
  - a. The Requirements, Capability, Complexity, and Release descriptive statements are comparative assessments against the previous OFP release.
  - b. The Baseline, Testing, Training/Documentation, and Hardware Change descriptive statements are stand alone assessments of the OFP effort under review.
2. Assign each attribute category a value of 0, 45, 55, or 100 based on results from step 1.
3. Sum the values across the eight attribute categories to calculate a total.
4. Classify the OFP effort as:
  - a. Maintenance : < 360
  - b. Development : > 440
  - c. Ambiguous : 360 – 440.

OFPs in this region require some other means of categorizing the work.

**Table 5. Guide to a quantitative OFP assessment**

Value	Requirements	Baseline	Capability	Complexity	Testing	Training Docs	Hardware change	Release interval
<b>0</b>	No new Requirements	Only product affected	No new capability	No Change/ Decrease	Bench Testing	No	No	<12 months
<b>45</b>	Few new requirements	Product and/or allocated affected	Few new capabilities	Minimal increase	Minimal Flight Testing			12-18 months
<b>55</b>	Many new requirements	Only allocated affected	Many new capabilities	Large Increase	Moderate Flight Testing			18-24 months
<b>100</b>	Extensive new requirements	Functional affected	Extensive new capabilities	Extensive Increase	Significant Flight Testing	Yes	Yes	>24 months

## QuOAT Model Description and Results

A scoring of various OFPs is depicted in Figure 26. These data were obtained via interviews of individuals with in-depth understanding of the OFP modification process. Each interviewee was provided a list of questions based on Table 5 and asked to assess their particular OFP modification effort. These questions can be found in Appendix F: QuOAT Interview Questions. Those interviewed were not told how each value related to the maintenance/development spectrum. This method was chosen to avoid prejudicing the results towards the interviewee's preconceived opinion about how OFP workload should be categorized. The results obtained by evaluating the interview data with the QuOAT perfectly matched the qualitative assessments the interviewees had already conducted. This validated the QuOAT's ability to quantify qualitative assessments.

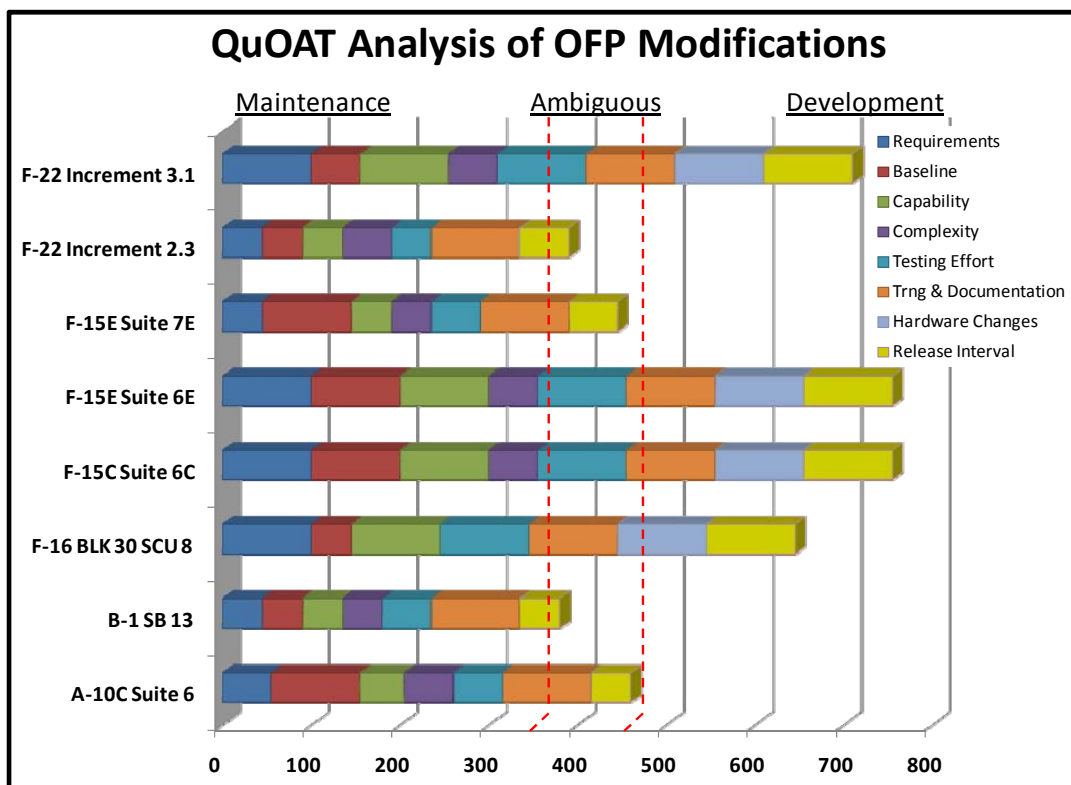


Figure 26. Quantitative analysis of OFP modifications

Application of the model to two different F-22 OFP releases serves as a good example of the tool's utility. F-22 Increment 2 Update 3 OFP is managed by the F-22 program office's sustainment division (Peet, 2010). QuOAT output for that OFP release was 390. This result was located in the ambiguous classification zone but slightly favored a "maintenance" classification. In contrast, the F-22 Increment 3.1 OFP is managed by the program office's modernization division (Peet, 2010). QuOAT assigned that OFP a value of 710, well above the minimum of 440 required for categorization as development. In this case, the organizational divisions of the F-22 program office reflect the nature of the OFP modification being managed (as characterized by the model). Minor updates to previous releases are labeled "sustainment" and major updates are labeled "modernization" (development).

The information obtained from QuOAT is most promising for its potential to influence decisions about the sustainment of software. QuOAT provides decision makers a means to assess whether a OFP modification effort lies within the boundaries of Title 10 sustainment law or without. Following this determination another decision remains: choosing between public and private sectors for the modification work.

## VII. Public and Private Sustainment Options for OFPs

With definitions established, law and policy reviewed, and models developed, the foundation is set for a consideration of how to allocate the OFP modification work of Air Force manned combat aircraft: to the public sector, to the private sector, or with a public-private partnership.

The early stages of this determination rely on definitions. Because Title 10 calls all software maintenance “depot-level maintenance”, if OFP modification post-IOC matches the definition of software maintenance, then it is a core candidate and the majority of the work may be allocated to the public sector via core capability policy. On the other hand, if OFP modification is classified as software development, core capability laws do not apply and the DoD will have greater flexibility in allocating the work according to other priorities, such as cost-effectiveness.

A second factor in allocating the work is grouping or binning the OFP work. Currently, all OFP modification work for a given aircraft type is considered in one large chunk. This work is normally categorized as core—contributing to an organic OFP capability. Another option is to consider each OFP release for a given aircraft type *separately*, determining each to be either maintenance or development by applying a model similar to the one summarized in Figure 24. As an example of extreme binning, a third option would be to label each separate line of code as maintenance or development, and allocate the labor hours according to the proportion of maintenance lines of code to development lines of code. This third option is impractical and is only mentioned as the

extreme opposite of current practice. These three binning options for the parsing of OFP workload are depicted in Figure 27.

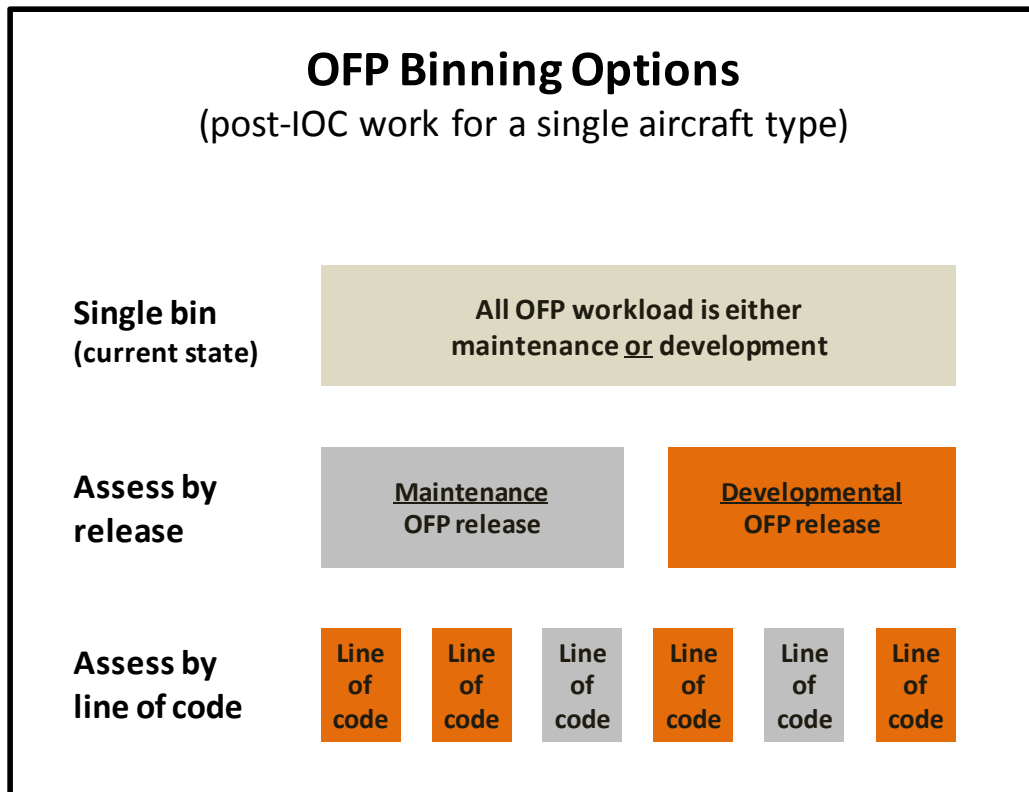


Figure 27. OFP binning options

The twin issues of definitions and OFP binning are now applied by way of example: F-22 OFP development. As stated earlier, OFP work managed by the F-22 program office is separated into two branches: sustainment and modernization. Increment 2, the first major OFP update following IOC in 2005, is managed by the sustainment branch. And this makes sense as much of the work involves correcting deficiency reports which document areas in which the OFP is not operating as planned or originally desired. Meanwhile, work on the next major release, dubbed increment 3.1, is

managed by the modernization branch because it involves significant new development. Increment 3.1 began with significant new requirements and a new Capability Production Document and added significant new capability to the F-22. This OFP release involves a multi-year development effort, hundreds of flight tests, and adds new features and capabilities to the aircraft requiring new operator training and changes to the operator's manual.

The management division between the sustainment effort for the previous OFP release (Increment 2) and the modernization/development effort for the next major release (Increment 3.1) reflects the nature of the software modifications being made. But while the models support this division, the F-22 OFP source of repair decision signed in 2007 classified all F-22 OFP modification workload as a core capability candidate. By legal implication, this classification declares all F-22 OFP modification work to be “software maintenance”.

To avoid the misclassification of OFP work, we recommend that OFPs for a given aircraft type be considered release by release (binning option #2 in Figure 27). This would require a source of work decision for each major OFP release, but would allow management decisions, workload allocation, and funding sources to reflect reality: new OFP releases are often *developmental* efforts.

### **Public-Private Partnering**

A hybrid depot maintenance option has grown into law and policy. Public-private partnering mitigates the tension between the classification of OFP work as supporting a core capability and the reality that much of the work is actually development and rightly



funded by development money. “Public-private partnering,” a formal term established by Title 10 section 2474 in 1998, is designed to increase efficiency by allowing equipment and facility sharing between public and private sectors. Partnering also intends to leverage the advantages of each sector by using both in the sustainment of military systems.

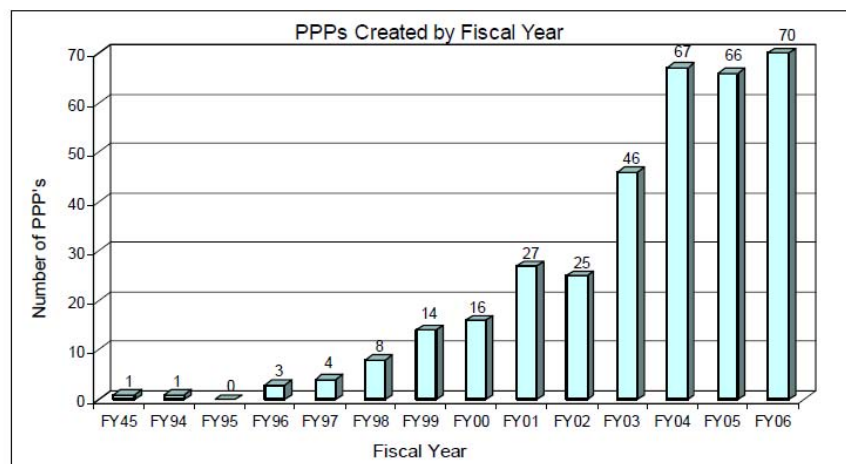
Partnering relationships between government and private depots were first encouraged in the National Defense Authorization Act of 1995. But other parts of the law, such as the core requirement and 50/50 funding law, were barriers to the establishment of partnerships. Subsequent NDAA’s provided increasing detail on partnerships, permitting the sharing of equipment and facilities and allowing receipts from partnerships to be credited to government depot accounts (Vitasek, Cothran, & Turner, 2007).

Partnering agreements exist in two basic categories. First, Workshare/Teaming arrangements allow the government and contractors to each perform their share of the workload and be paid separately by the government customer (Vitasek, Cothran, & Turner, 2007). For example, a private depot might be paid to maintain 30% of F-35 engines while the government depot maintains 70% of the engines. Or the work may be split between disassembly/inspection and reassembly/testing.

The second category of partnering is Direct Sales arrangements. The contractor is paid by the government but sub-contracts to the government depot to actually perform the maintenance (Vitasek, Cothran, & Turner, 2007). In essence, the government depots act as sub-contractors to private industry.

The key advantage of partnering is that contractor work performed in a government facility can be counted toward core labor hours (Vitasek, Cothran, & Turner, 2007). Partnering ensures that core laws are satisfied while keeping both industry and government employed and current in defense systems. Commercial best practices are leveraged while maximizing use of government facilities and equipment (Vitasek, Cothran, & Turner, 2007). As the Undersecretary of Defense for Logistics and Materiel Readiness stated, “DoD's goals for depot maintenance public private partnerships are: more responsive product support, better facility utilization, reduced cost of ownership, and more efficient business processes” (Bell, 2007)

Public-private partnerships are increasingly common, as shown in Figure 28. In the case of combat aircraft OFPs, private companies who develop the aircraft are the most skilled in modifying the OFP. Partnering allows the government to become skilled in OFP modification for eventual ownership of the process. Reasons for this move from private to public OFP modification over the life of an aircraft are addressed in the next chapter.



**Figure 28. Growth of Public-Private Partnerships (The Joint Maintenance Activities Group, 2007)**

The three options for OFP modification workload allocation are compared and contrasted in Figure 29. While the context for work accomplished under any of the three options is generally “depot maintenance,” these same options exist for allocation of development work. However, as OFP modification on Air Force aircraft is typically designated a core workload, OFP development post-IOC is allocated to one of these three options in a “software maintenance” context.

<b>OFP Modification: Workload Allocation Options</b>			
	<b>Private</b>	<b>Partnership</b>	<b>Public (Organic*)</b>
<b>Pros</b>	<ul style="list-style-type: none"> <li>• Incentive to innovate</li> <li>• Prior system experience</li> <li>• Supports shrinking industrial base</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibility</li> <li>• Improved Business Practices</li> <li>• Increased gov facility utilization</li> <li>• Satisfies Title 10</li> <li>• Jobs for voters (compared to private option)</li> </ul>	<ul style="list-style-type: none"> <li>• Satisfies Title 10</li> <li>• Reduces risk to government</li> <li>• Jobs for voters</li> </ul>
<b>Cons</b>	<ul style="list-style-type: none"> <li>• Does not satisfy Title 10 for “maintenance” activities</li> <li>• Gov loses technical skill required for oversight</li> </ul>	<ul style="list-style-type: none"> <li>• Cost-savings are debatable</li> <li>• Private industry may dislike relying on gov work for a PBL contract</li> </ul>	<ul style="list-style-type: none"> <li>• Lacks skill/innovation from private industry</li> <li>• Profit motive absent</li> </ul>

\*Title 10 Section 2464 requires an organic depot capability within 4 years of IOC for core workloads

**Figure 29. Pros and Cons of Public and Private Depots**

### **Summary: Public and Private Sustainment Options for OFPs**

Workload associated with the modification of USAF combat aircraft OFPs today is usually designated core and is therefore subject to Title 10 core logistics requirements. Workload allocation is normally not re-categorized for subsequent OFP releases. An OFP workload is generally classified as core at the beginning of an aircraft program and remains core for the life of the aircraft.

The organization of some aircraft program offices reflects the reality that much OFP modification is development/modernization and not maintenance. Sources of funding used for OFP modification work vary greatly from aircraft to aircraft, as considered in previous chapters. Some use mostly development money while others rely on operations and maintenance funds.

Partnering agreements between public depots and private contractors are increasing in number. Such agreements allow the leveraging of the strengths of both the public and private sectors while satisfying Title 10 core logistics laws. But should such arrangements be used for OFP development as well as maintenance? We answer this question through several summary conclusions and recommendations.

## **VIII. Conclusions and Recommendations**

The three primary objectives of this research were to:

1. Better understand a complex web of law, policy, and practice regarding the application of Title 10 depot maintenance requirements.
2. Propose a common dictionary of terms for use in policy and regulations.
3. Propose a more flexible model for avionics software source of repair decisions.

To meet these objectives, the following subjects were researched and analyzed:

- Title 10 law and resulting DoD and Air Force policies.
- Fundamental differences between hardware and software sustainment.
- How software sustainment should be distinguished from software modernization/development.
- Public-private partnerships in the context of software sustainment.

With this foundation, the following conclusions and recommendations are made:

### **#1 - Institute a Common Dictionary**

As a first step in unraveling the complex web of core logistics law and policy confusion, we recommend the proposed common taxonomy of software maintenance and development terms, proposed in this research, be universally established within the DoD. A clear, common, and consistent glossary regarding core capability determination should be included in DoD and Air Force policy documents and downstream handbooks and guidebooks. Acquisition education should also include clear instruction on these

definitions so that future acquisition professionals have the tools required to make consistent decisions about the allocation of OFP workloads.

The following definitions are proposed:

- **Hardware Maintenance/Sustainment:**
  - *Material repair, overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment which restores or retains the originally designed functionality.*
- **Software Maintenance/Sustainment:**
  - *Reactive modification of a software product performed after delivery to correct discovered faults, keep a computer program usable in a changed software environment or improve its processing performance or maintainability*
- **Software Modernization (Development after initial release):**
  - *Modification of software that adds new capabilities, changes the functional baseline, significantly increases complexity, or responds to significant new user requirements.*

## **#2 – Use QuOAT to Assess Each OFP Release as Maintenance or Development**

Second, we recommend accomplishing an assessment of each major OFP release. Military aircraft OFP development is often not software maintenance and the workload associated with a given OFP should not be designated “core” by default. OFP development often involves new user requirements, significant new capability, and requires extensive developmental and operational testing prior to release. Each major OFP release should be classified as development or maintenance according to the common lexicon aided by the qualitative model and quantitative (QuOAT) assessment tool proposed in this research.

The division of labor between public and private sectors might be changed significantly by these first two recommendations. However, several advantages exist. First, the official classification given to OFP work will more closely match the nature of the work being done and type of funding employed. A major OFP release that is mostly development work will be classified as development, and core maintenance laws would not apply. The DoD and its program managers would be afforded greater flexibility in allocating workloads for OFP modification.

### **#3 - Pursue Public-Private Partnerships for Development and Maintenance**

The government should maintain a depot maintenance capability to build the skills and knowledge required to maintain technical oversight of private contractors, increase competition for work, add workforce during time of need, and prepare for the transition from partnerships to full government sustainment when appropriate. Partnering would remain a good option for both OFP maintenance/sustainment and development. Partnering agreements would no longer serve as a means to satisfy core workload levels inflated by OFP development work misclassified as maintenance.

Instead, a typical OFP logistics plan would include an incremental transition from primarily private work to primarily government work over the life of a system. Private industry would perform the initial development prior to IOC and maintain the OFP for several years following IOC. At this point the government would partner with industry to maintain those OFP releases classified as maintenance, gaining familiarity and expertise in that OFP family. The contractor would focus on *development* of the next major release (not counted toward core labor hours). Over time the contractor's interest might move

toward new aircraft systems, and the government would pick up the majority of work late in the aircraft's life when OFP development is likely to decrease.

This arrangement would allow the government to gain technical understanding of and skill with an OFP early in the life cycle in preparation for later years when a particular OFP would move into a sustainment period. Government involvement through partnering would also allow the government to maintain credible technical oversight of progress on the contractor's portion of the work. The life cycle plan for OFP development and sustainment could then be tailored for each aircraft program. Some might be heavily developmental for a long period and the government's role would be smaller for a longer period of time. Other programs may transition to primarily government work earlier. This increase in flexibility would be an improvement over the current inflexible approach whereby all OFP modification is considered software maintenance and work allocation is subject to Title 10.

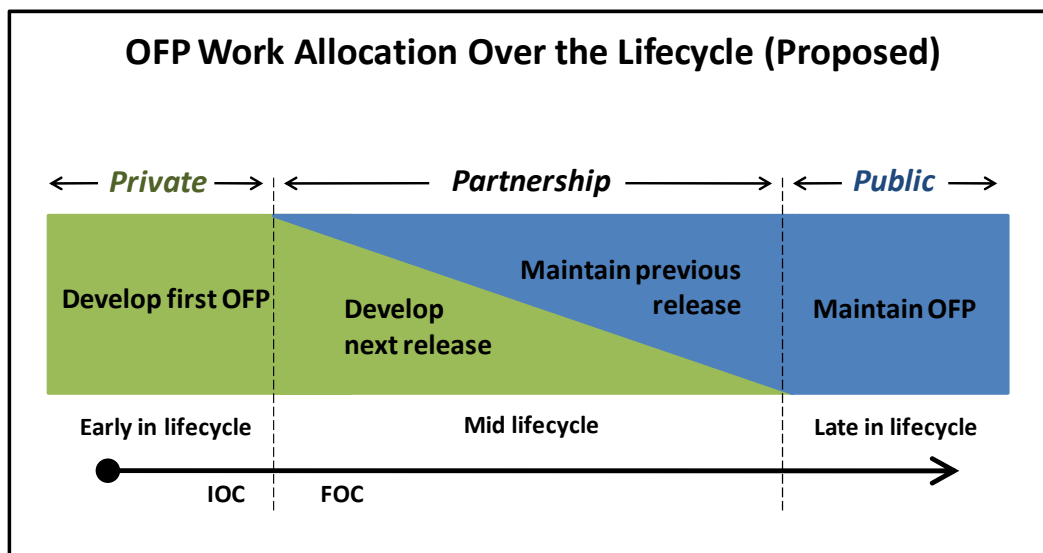


Figure 30. OFP work allocation over the lifecycle



In summary, the work on a single OFP release would generally move from left to right in Figure 30. As the operational OFP release moves to the right, the next release begins at left and slowly moves right over time, as the government's proportion of the partnership work increases. This is intended as a notional plan only. OFPs of specific aircraft might vary from this plan. A partnership may exist until the system is disposed, or OFP work might be all public earlier than depicted. After establishing clear definitions, this general arrangement could be implemented with minimal changes to existing policy.

#### **#4 - Add a Risk Assessment to Title 10**

The motivation for Title 10's requirement to maintain an organic depot maintenance and repair capability is rooted in a Cold War prolonged hardware-centric conflict that is no longer applicable today because the risk of private sustainment is decreased. Therefore, this research recommends that Title 10 be amended to allow a risk assessment prior to entering the core capability determination process. For example, if an OFP release were determined to be maintenance and therefore subject to Title 10 core requirements, a risk assessment would be performed before work allocation. If the risk to the government were assessed as low, the work might be given to the private sector even though the workload would be core. If the OFP work were classified as development and therefore not a core capability, this risk analysis would not be applicable. But for any system workload that is designated as supporting a core capability, the risk analysis may reveal low risk situations where other decision factors such as cost-effectiveness should have higher priority.

This recommendation is depicted by way of a new functional model in Figure 31. Added items are shown in red for comparison with the “as-is” architecture in (Figure 15). If the risk analysis assesses high risk of reliance on the private sector, then the work hours continue into the core and 50/50 calculations. If the risk is assessed as low, the option exits to bypass core calculations and enter at 50/50 calculations.

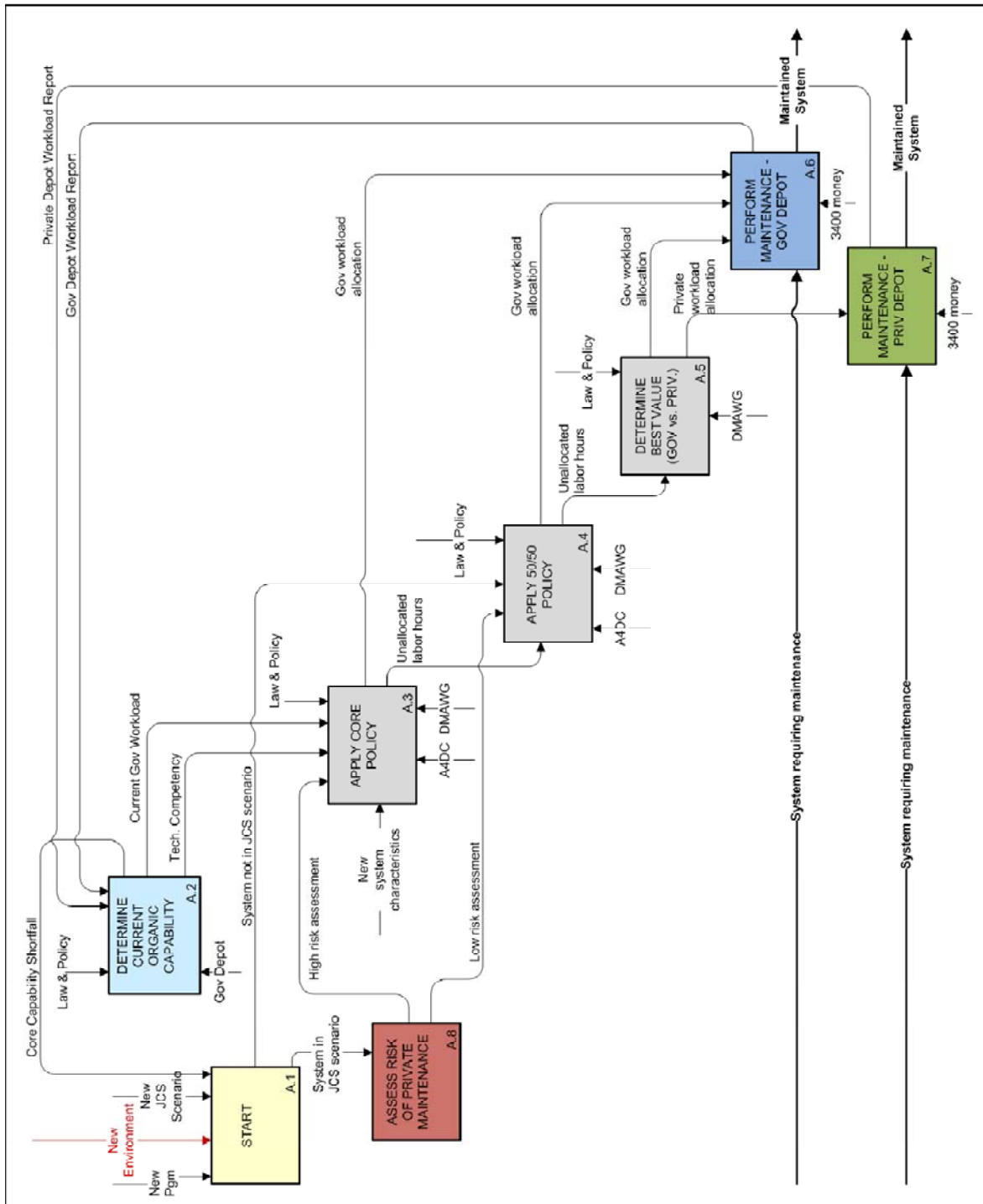


Figure 31. SORAP decision process (to-be)

## **#5 - Remove the Four Year Post-IOC Deadline from Title 10**

Title 10 Section 2464 requires establishing an organic maintenance capability within *four* years after IOC for a new system. This timeline is arbitrary and best applied to hardware which reaches some measure of stability after IOC. OFPs often do not reach a stable state as new releases are developed to support significant new requirements and capabilities. This research recommends that this requirement in Title 10 be removed. DoD policy should require program managers, in conjunction with AFMC headquarters, to plan depot workload allocations for the entire lifecycle in a manner that suits the program under consideration. An OFP's lifecycle logistics plan should be flexible – designed for smooth transition from private development to a sustainment partnership between government and private sectors, and then to wholly government sustainment if and when appropriate.

## **Suggested Future Research**

The models proposed by this research could be expanded and improved for greater application and accuracy. Expanding the research beyond combat Air Force programs might reveal more ways to characterize an OFP. The models should be further validated by applying them to a greater number of historical OFPs in multiple types of aircraft systems.

Second, tools should be developed to aid in the proposed risk assessment. Such a model might include a measure of the health of private industry, the characteristics of the warfare environment for the system in question, and characteristics of the system itself.

The tool's output would be a prediction of risk to the government of relying on the private sector for depot-level sustainment of the system.

Third, research should be conducted into funding practices by program offices. If common definitions are proposed and OFP modification work is methodically categorized as maintenance or development, funding appropriate to workload classification should be planned, programmed, and budgeted. Currently, the program offices interviewed are using funding that is available or that subjectively matches the work at hand. Some offices are using development money, while others tap operations and maintenance funds for similar work. It would be ideal for the classification of the work, the characteristics of the work, and the funding source to all match each other. Development work should be categorized as development and funded with development funds.

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## Appendix A: Definitions

**Table 6. Various Definitions Relating to the Sustainment, Maintenance, and Modification of Software**

	Sustainment	Maintenance	Software Specific Terms	Related terms
<p><b><u>Title 10 Sec 2464</u></b></p> <p><b>Definition of Depot Level Maintenance and Repair</b></p> <p>1996 SW added to law (2466)</p>	None	<p>Material maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary, regardless of the source of funds for the maintenance or repair or the location at which the maintenance or repair is performed. The term includes (1) all aspects of software maintenance as depot-level maintenance and repair, and (2) interim contractor support or contractor logistics support (or any similar contractor support), to the extent that such support is for the performance of services described in the preceding sentence.</p> <p>(b) Exceptions. - (1) The term does not include the procurement of major modifications or upgrades of weapon systems that are designed to improve program performance.</p>	None	None

	Sustainment	Maintenance	Software Specific Terms	Related terms
<b><u>DoD 5000.01</u></b> <b>The Defense Acquisition System</b>	None	None	None	None
<b><u>DoD 5000.02</u></b> <b>Operation of the Defense Acquisition System</b>	Life-cycle sustainment planning and execution seamlessly span a system's entire life cycle, from Materiel Solution Analysis to disposal. It translates force provider capability and performance requirements into tailored product support to achieve specified and evolving life-cycle product support availability, reliability, and affordability parameters.	None	None	None
<b><u>DoD 7000.14-R V2A</u></b> <b>Budget Formulation and Presentation</b>	Depot and field level maintenance is the routine, recurring effort conducted to sustain the operational availability of an end item.	<p>Depot and field level maintenance includes refurbishment and overhaul of end items, removal and replacement of secondary items and components, as well as repair and remanufacturing of reparable components. The maintenance effort may be performed by government agency or by a contractor.</p> <p>Maintenance, repair, overhaul, and rework of equipment are funded in the operation and maintenance appropriations. However, maintenance of</p>		d. Continuous technology refreshment is the intentional, incremental insertion of newer technology to improve reliability, improve maintainability, reduce cost, and/or add minor performance enhancement, typically in conjunction with depot or field level maintenance. The insertion of such technology into end items as part of maintenance is funded by the operation and maintenance appropriations. However, technology refreshment that significantly changes the performance envelope of the

	Sustainment	Maintenance	Software Specific Terms	Related terms
		equipment used exclusively for research, development, test, and evaluation efforts will be funded by the RDT&E appropriations.		end item is considered a modification and, therefore, an investment (See section on “Product Improvement” 010212 C. 7.). This definition applies equally to technology insertion by commercial firms as part of contractor logistics support, prime vendor, and similar arrangements and to technology insertion that is performed internally by the Department.
<b><u>DODD 4151.18</u></b> <b>Maintenance of Military Materiel</b>	None	Maintenance tasks restore safety and reliability to their inherent levels when deterioration has occurred.	None	None
<b><u>DoD 4151.18-H</u></b> <b>Depot Maintenance Capacity and Utilization Measurement Handbook</b>	Core-sustaining workload ensures technical competence in peacetime while preserving the surge capacity and reconstitution capabilities necessary to fully support the strategic and contingency plans prepared by the Chairman of the Joint Chiefs of Staff.	The processes of materiel maintenance or repair involving the overhaul, upgrading, rebuilding, testing, inspection, and reclamation (as necessary) of weapons systems, equipment end items, parts, components, assemblies, and subassemblies. Depot maintenance also includes all aspects of software maintenance, the installation of parts or components for modifications, and technical assistance to intermediate maintenance organizations, operational units and other	None	None



Sustainment		Maintenance	Software Specific Terms	Related terms
		activities. Depot maintenance is typically accomplished in fixed shops, shipyards and other shore-based facilities, or by field teams, using more extensive shop facilities, equipment, and personnel of higher technical skill than are available at lower echelons of maintenance.		
<b><u>DODI 4151.20</u></b>  <b>Depot Maintenance Core Capabilities Determination Process</b>	None	The processes of materiel maintenance or repair involving the overhaul, upgrading, rebuilding, testing, inspection, and reclamation (as necessary) of weapons systems, equipment end items, parts, components, assemblies, and subassemblies. Depot maintenance also includes all aspects of software maintenance;	Software. A set of computer programs, procedures, and associated documentation concerned with the operation of a data-processing system (e.g., compilers, library routines, manuals, and circuit diagrams).	None
<b><u>DODI 4151.21</u></b>  <b>Public-Private Partnerships for Depot-Level Maintenance</b>	None	The processes of materiel maintenance or repair involving the overhaul, upgrading, rebuilding, testing, inspection, and reclamation (as necessary) of weapon systems, equipment end items, parts, components, assemblies, and subassemblies. Depot-level maintenance also includes all aspects of software maintenance, the installation of parts or components for	None	None

Sustainment	Maintenance	Software Specific Terms	Related terms
	<p>modifications, and technical assistance to intermediate maintenance organizations, operational units, and other activities.</p> <p><b>Depot-level maintenance activity.</b> A specific DoD-owned and DoD-operated facility established, equipped, and staffed to carry out depot-level maintenance. DoD depot-level maintenance activities accomplish a wide range of depot-level maintenance processes including overhaul, conversion, activation, inactivation, renovation, analytical rework, repair, modifications and upgrades, inspection, manufacturing, reclamation, storage, software support, calibration, and technical assistance.</p>		
<p><b><u>DODI 4151.22</u></b></p> <p><b>Condition Based Maintenance Plus for Materiel Maintenance</b></p>	<p>None</p>	<p>Maintenance can be performed using a wide variety of approaches. Two main categories of maintenance – reactive and proactive – are provided to describe the range of options available.</p> <p><b>Reactive maintenance</b> (i.e.,</p>	<p>None</p>

	Sustainment	Maintenance	Software Specific Terms	Related terms
		<p>corrective maintenance). Performed for items that are selected to run to failure or those items that fail in an unplanned or unscheduled manner. Run to failure is often the planned maintenance strategy for items that have little readiness or safety impact.</p> <p><b>Proactive maintenance.</b> This type of maintenance can be considered as either preventive or predictive in nature, and the maintenance performed includes inspection, assessment, test, diagnostics, prognostics, servicing, and scheduled replacement/overhaul.</p>		
<p><b><u>JP 1-02</u></b></p> <p><b>Department of Defense Dictionary of Military and Associated Terms</b></p>	<p><b>Sustainment</b> — The provision of logistics and personnel services required to maintain and prolong operations until successful mission accomplishment</p>	<p><b>Maintenance (materiel)</b> — 1. All action taken to retain materiel in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, and classification as to serviceability, repair, rebuilding, and reclamation.</p> <p>2. All supply and repair action taken to keep a force in condition to carry out its mission.</p> <p>3. The routine recurring work required to keep a facility (plant,</p>	None	None

	Sustainment	Maintenance	Software Specific Terms	Related terms
		<p>building, structure, ground facility, utility system, or other real property) in such condition that it may be continuously used at its original or designed capacity and efficiency for its intended purpose.</p> <p><b>materiel</b> — All items (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinction as to its application for administrative or combat purposes. See also <b>equipment</b>;</p>		
<b><u>JP 3-0</u></b> <b>Joint Operations</b>	<p>The <b>sustainment function</b> encompasses a number of tasks including:</p> <p>(2) Providing for maintenance of equipment.</p>	None	None	None
<b><u>JP 4-0</u></b> <b>Joint Logistics</b>	<b>Sustainment</b> is the provision of logistics and personnel services necessary to maintain and prolong operations until successful mission completion.	Maintenance is accomplished across DoD at two levels: depot level (sustainment) and field level (intermediate and organizational).	None	None

	Sustainment	Maintenance	Software Specific Terms	Related terms
		<p>(1) Depot Maintenance Operations. The purpose of depot maintenance is to repair, modify, rebuild, and overhaul both entire systems and components.</p> <p>(2) Field Maintenance Operations. The purpose of field level maintenance is to rapidly return systems to users in a ready status.</p>		
<b><u>AFPD 63-1</u></b>  <b>Acquisition and Sustainment Life Cycle Management</b>	<b>Sustainment</b> —continuing materiel support which consists of the planning, programming, and execution of a logistics support strategy for a system, subsystem, or major end-item to maintain operational capabilities from system fielding through disposal.	None	None	<b>Modification</b> —a modification is defined as a change to the form, fit, function, or interface (F3I) of an in-service, configuration-managed AF asset.
<b><u>AFI 63-101</u></b>  <b>Acquisition and Sustainment Life Cycle Management</b>	<b>Sustainment</b> —Continuing materiel support which consists of the planning, programming, and execution of a logistics support strategy for a system, subsystem, or major end item to maintain operational capabilities from system fielding through disposal.	None	<b>Software Maintenance</b> —Those activities necessary to correct errors in the software; add incremental capability improvements (or delete unneeded features) through software changes; and adapt software to retain compatibility with hardware or with other systems with which the software interfaces. Software maintenance comprises software	<b>Modification</b> —For the purposes of this instruction, a modification is defined as a change to the form, fit, function, or interface (F3I) of an in-service, configuration-managed AF asset. Modifications are primarily defined by their purpose. A capability modification alters the F3I of an asset in a manner that requires a change to the existing system, performance, or

Sustainment	Maintenance	Software Specific Terms	Related terms
		<p>maintenance performed on military materiel (e.g. weapon systems and their components, space control systems and their components, automated test equipment and test package sets, and systems integration laboratories).</p>	<p>technical specification of the asset. Such modifications are generally accomplished to add a new capability or function to a system or component, or to enhance the existing technical performance or operational effectiveness of the asset.</p> <p>A sustainment modification alters the F3I of an asset in a manner that <i>does not</i> change the existing system, performance, or technical specification of the asset. Such modifications are generally accomplished to correct product quality deficiencies, or to bring the asset in compliance with, or to maintain the established technical or performance specification(s) associated with the asset. Sustainment modifications may also include efforts that are accomplished for the primary purpose of improving the reliability, availability, maintainability, or supportability of an asset, or to reduce its ownership costs.</p>
AFI 63-107 (replaced by	Sustainment is the planning, programming and executing of a support strategy for a system,	<b>Maintenance:</b> the orderly arrangement of all maintenance support, including support	<b>Software Maintenance</b> —Those activities necessary to: 1) correct
			Acquisition is the conceptualization, initiation, design, development, test,

	Sustainment	Maintenance	Software Specific Terms	Related terms
AFI 63-101)	subsystem or major end item to maintain operational capabilities from system fielding through disposal.	<p>equipment and facilities, to keep systems and equipment ready to perform assigned missions. This includes all levels of maintenance and implementation of those levels (includes any partnering, organic and contract support).</p> <p><b>Depot Maintenance</b>—Materiel maintenance or repair performed by contractor or organic depots requiring the overhaul or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary. The term includes all aspects of software maintenance as classified by the DoD as of 1 July 1995 as depot level maintenance and repair.</p>	<p>errors in the software;</p> <p>2) add incremental capability improvements (or delete unneeded features) through software changes; and</p> <p>3) adapt software to retain compatibility with hardware or with other systems with which the software interfaces. Software maintenance comprises software maintenance performed on military materiel (e.g. weapon systems and their components, space control systems and their components, automated test equipment and test package sets, and systems integration laboratories).</p>	<p>contracting, production and deployment of a directed and funded effort that provides a new, improved or continued materiel, weapon, information system or service capability in response to an approved need.</p> <p><b>Modification</b>—An alteration to a configuration item applicable to aircraft, missiles, support equipment, ground stations software (imbedded), trainers, etc. As a minimum, the alteration changes the form, fit, function or interface of the item.</p>
<u>AFI 65-601v1</u>  <b>Budget Guidance and Procedures</b>		<p><b>Maintenance</b>—The routine, recurring work necessary to keep an end item of equipment or configuration item at its current or intended operation capability or designed performance.</p>	<p><b>Computers: Software Maintenance</b>—Efforts associated with eliminating faults in software to ensure that an information system (IS) or application is in a satisfactory working condition.</p> <p><b>Computers: Weapon Support Systems Embedded Computers</b>— Embedded computers are those integral to</p>	<p><b>Computers: Software Changes</b>— Efforts associated with revision or alteration of an existing IS or application to support the changes in design specification required by the functional manager and higher authority. It encompasses changing programs, reformatting, and documentation thereof. Software conversions are funded as software changes.</p>

	Sustainment	Maintenance	Software Specific Terms	Related terms
			weapon systems, intelligence systems, command and control systems, communication systems, and other support systems and facilities, such as automatic test equipment, simulators and other training devices, etc. This includes computer resources acquired and managed per acquisition instructions (AFI 63-xxx series and DODI 5000.2). These computers are integral to and in direct support of a major system or a less-than-major system.	<b>Development Engineering</b> — Development engineering includes the engineering effort required to define, develop, optimize, design, integrate, test, evaluate, and verify a new weapon system, equipment, modification, or other product prior to production. Also applicable to extensive redesign and requalification of an existing item or system (including embedded ADP systems, both hardware and software).
<b><u>T.O. 00-25-4</u></b>  <b>Depot Maintenance of Aerospace Vehicles and Training Equipment</b>	None	The level of maintenance consisting of those on and off-equipment tasks performed using highly specialized skills, sophisticated shop equipment, or special facilities of an ALC, centralized repair activity, contractor facility, or, by field teams at an operating location.	None	<b>Modification</b> - A physical alteration of equipment that changes its capabilities or characteristics, i.e., form, fit or function.
<b><u>GSAM Handbook</u></b>  <b>Guidelines for Successful Acquisition and Management of Software Intensive</b>	Sustainment is often thought of in the context of fixing bugs, but it can be of four different types, depending on the reason or need. While a sustainment effort may be precipitated by a single type of sustainment need, most	None	<b>Maintenance Phase</b> includes fixing errors and modifying or upgrading the software to provide additional functionality, such as enabling the software to work with new computing platforms	None



	Sustainment	Maintenance	Software Specific Terms	Related terms
Systems	<p>efforts include two or more sustainment types. The four types are summarized here. [2]</p> <ol style="list-style-type: none"> <li><b>1. Corrective Sustainment</b> – diagnosis and correction of program errors after its release.</li> <li><b>2. Perfective Sustainment</b> – the addition of new capabilities and functionality to existing software.</li> <li><b>3. Adaptive Sustainment</b> – modification of software to interface with a changing environment.</li> <li><b>4. Preventive Sustainment</b> – modification of software to improve future maintainability or reliability.</li> </ol> <p>Corrective sustainment requires examination of the existing program code to determine the cause of the error, analysis to determine the best way to correct the error without introducing new errors, and regression testing to validate that the original error has been eliminated without introducing new errors. Perfective and Adaptive sustainment usually involve a complete development</p>			

	Sustainment	Maintenance	Software Specific Terms	Related terms
	effort with requirements, design, coding, and integration and test phases. Preventive sustainment is performed by reverse engineering the existing software and re-engineering (redeveloping) it.			
<b>IEEE 610.12-1990</b>  <b>Standard Glossary of Software Engineering Terms</b>	None	<p><b>Maintenance.</b> (1) The process of modifying a software system or component after delivery to correct faults, improve performance or other attributes, or adapt to a changed environment.</p> <p><i>Syn:</i> <b>software maintenance. See also: adaptive maintenance; corrective maintenance; perfective maintenance.</b></p> <p>(2) The process of retaining a hardware system or component in, or restoring it to, a state in which it can perform its required functions. <i>See also:</i> <b>preventive maintenance</b></p>	<p><b>Software maintenance. See: maintenance (1).</b></p> <p><b>Adaptive Maintenance.</b> Software maintenance performed to make a Computer program usable in a changed environment.</p> <p><b>Corrective Maintenance.</b> Maintenance performed to correct faults in hardware or software.</p> <p><b>Perfective Maintenance.</b> Software maintenance performed to improve the performance, maintainability, or other attributes of a computer program.</p>	<p><b>Software development cycle.</b> The period of time that begins with the decision to develop a software Product and ends when the software is delivered. This cycle typically includes a requirements phase, design phase, implementation phase, test phase, and sometimes, installation and checkout phase.</p> <p><b>Contrast with: software life cycle.</b></p> <p><b>Notes: (1)</b> The phases listed above may overlap or be performed iteratively, depending upon the software development approach used.</p> <p><b>(2)</b> This term is sometimes used to mean a longer period of time, either the period that ends when the software is no longer being enhanced by the developer, or the entire software life cycle.</p>

	Sustainment	Maintenance	Software Specific Terms	Related terms
				<p><b>Software life cycle.</b> The period of time that begins when a software product is conceived and ends when the software is no longer available for use. The software life cycle typically includes a concept phase, requirements phase, design phase, implementation phase, test phase, installation and checkout phase, operation and maintenance phase, and, sometimes, retirement phase.</p> <p><b>Note:</b> These phases may overlap or be performed iteratively.</p> <p><b>Contrast with: software development cycle.</b></p>
<p><u>IEEE 1219-1992</u></p> <p>Standard for Software Maintenance</p>	None	None	<p><b>Software maintenance:</b></p> <p>Modification of a software product after delivery to correct faults, to improve performance or other attributes, or to adapt the product to a modified environment.</p> <p><b>Adaptive maintenance:</b></p> <p>Modification of a software product performed after delivery to keep a computer program usable in a changed or changing environment.</p> <p><b>Corrective maintenance:</b></p>	None

Sustainment	Maintenance	Software Specific Terms	Related terms
		<p>Reactive modification of a software product performed after delivery to correct discovered faults.</p> <p><b>Emergency maintenance:</b>            Unscheduled corrective maintenance performed to keep a system operational.</p> <p><b>Perfective maintenance:</b>            Modification of a software product after delivery to improve performance or maintainability.</p>	
<p><u>NAVAIR Software Logistics Primer</u></p>	<p><b>Software Support Activity (SSA) -</b>            A Software Support Activity assumes the role of providing post-deployment life cycle support for modifications or upgrades made to a system's software following the system's initial fielding. System modifications and upgrades include multi-system changes, block changes, preplanned product improvements, repair of deficiencies reported by the user, and other types of system change packages. The SSA organization typically compiles these needed updates into formal software releases to avoid disrupting the fielded system. Software development activities</p>	<p><b>Software Maintenance</b> (a.k.a. software sustainment) -            Modification of a software product after delivery to correct faults, to improve performance or other attributes, or to adapt the product to a modified environment. Software maintenance typically consists of the following activities:</p> <p><b>Corrective maintenance:</b>            reactive modification to correct discovered problems</p> <p><b>Adaptive maintenance:</b>            modification to keep software usable in a changed environment</p> <ul style="list-style-type: none"> <li>• <b>Perfective:</b> modification to improve performance or</li> </ul>	

	Sustainment	Maintenance	Software Specific Terms	Related terms
	performed by a SSA in providing life cycle support are the same as those carried out during the development effort that led to the first fielding. They are tailored, as appropriate, to reflect the effort required to implement each change package, update pertinent documentation, verify the changes, and distribute the changes to users.		maintainability <ul style="list-style-type: none"> <li>• <b>Preventive:</b> modification to detect and correct latent faults</li> </ul>	
<u><b>USAF Weapon Systems Software Management Guidebook</b></u>			Software repair involves returning a deficient design to specification or incorporating new requirements (originated or derived). The processes required to repair or maintain software are very similar to those used to develop it. Software repair requires requirement trades, design reiteration, interface control, prototyping, integration, testing, verification, fielding planning, and metrics.	

## **Appendix B: Text of United States Code, Title 10**

(those Sections relevant to the requirement for organic core logistics)

### **Section 2464**

[\(link: return to document\)](#)

#### **Core logistics capabilities**

##### **(a) Necessity for Core Logistics Capabilities.—**

(1) It is essential for the national defense that the Department of Defense maintain a core logistics capability that is Government-owned and Government-operated (including Government personnel and Government-owned and Government-operated equipment and facilities) to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements.

(2) The Secretary of Defense shall identify the core logistics capabilities described in paragraph (1) and the workload required to maintain those capabilities.

(3) The core logistics capabilities identified under paragraphs (1) and (2) shall include those capabilities that are necessary to maintain and repair the weapon systems and other military equipment (including mission-essential weapon systems or materiel not later than four years after achieving initial operational capability, but excluding systems and equipment under special access programs, nuclear aircraft carriers, and commercial items described in paragraph (5)) that are identified by the Secretary, in consultation with the Chairman of the Joint Chiefs of Staff, as necessary to enable the armed forces to fulfill the strategic and contingency plans prepared by the Chairman of the Joint Chiefs of Staff under section 153 (a) of this title.

(4) The Secretary of Defense shall require the performance of core logistics workloads necessary to maintain the core logistics capabilities identified under paragraphs (1), (2), and (3) at Government-owned, Government-operated facilities of the Department of Defense (including Government-owned, Government-operated facilities of a military department) and shall assign such facilities sufficient workload to ensure cost efficiency and technical competence in peacetime while preserving the surge capacity and reconstitution capabilities

necessary to support fully the strategic and contingency plans referred to in paragraph (3).

(5) The commercial items covered by paragraph (3) are commercial items that have been sold or leased in substantial quantities to the general public and are purchased without modification in the same form that they are sold in the commercial marketplace, or with minor modifications to meet Federal Government requirements.

**(b) Limitation on Contracting.—**

(1) Except as provided in paragraph (2), performance of workload needed to maintain a logistics capability identified by the Secretary under subsection (a)(2) may not be contracted for performance by non-Government personnel under the procedures and requirements of Office of Management and Budget Circular A–76 or any successor administrative regulation or policy (hereinafter in this section referred to as OMB Circular A–76).

(2) The Secretary of Defense may waive paragraph (1) in the case of any such logistics capability and provide that performance of the workload needed to maintain that capability shall be considered for conversion to contractor performance in accordance with OMB Circular A–76. Any such waiver shall be made under regulations prescribed by the Secretary and shall be based on a determination by the Secretary that Government performance of the workload is no longer required for national defense reasons. Such regulations shall include criteria for determining whether Government performance of any such workload is no longer required for national defense reasons.

**(3)**

(A) A waiver under paragraph (2) may not take effect until the expiration of the first period of 30 days of continuous session of Congress that begins on or after the date on which the Secretary submits a report on the waiver to the Committee on Armed Services and the Committee on Appropriations of the Senate and the Committee on Armed Services and the Committee on Appropriations of the House of Representatives.

(B) For the purposes of subparagraph (A)—

(i) continuity of session is broken only by an adjournment of Congress sine die; and

(ii) the days on which either House is not in session because of an adjournment of more than three days to a day certain are excluded

in the computation of any period of time in which Congress is in continuous session.

**(c) Notification of Determinations Regarding Certain Commercial Items.—**

The first time that a weapon system or other item of military equipment described in subsection (a)(3) is determined to be a commercial item for the purposes of the exception contained in that subsection, the Secretary of Defense shall submit to Congress a notification of the determination, together with the justification for the determination.

The justification for the determination shall include, at a minimum, the following:

- (1) The estimated percentage of commonality of parts of the version of the item that is sold or leased in the commercial marketplace and the Government's version of the item.
- (2) The value of any unique support and test equipment and tools that are necessary to support the military requirements if the item were maintained by the Government.
- (3) A comparison of the estimated life cycle logistics support costs that would be incurred by the Government if the item were maintained by the private sector with the estimated life cycle logistics support costs that would be incurred by the Government if the item were maintained by the Government.



## **Section 2460**

[\(link: return to document\)](#)

### **Definition of depot-level maintenance and repair**

#### **(a) In General.—**

In this chapter, the term “depot-level maintenance and repair” means (except as provided in subsection (b)) material maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary, regardless of the source of funds for the maintenance or repair or the location at which the maintenance or repair is performed. The term includes

- (1) all aspects of software maintenance classified by the Department of Defense as of July 1, 1995, as depot-level maintenance and repair, and
- (2) interim contractor support or contractor logistics support (or any similar contractor support), to the extent that such support is for the performance of services described in the preceding sentence.

#### **(b) Exceptions.—**

- (1) The term does not include the procurement of major modifications or upgrades of weapon systems that are designed to improve program performance or the nuclear refueling of an aircraft carrier. A major upgrade program covered by this exception could continue to be performed by private or public sector activities.
- (2) The term also does not include the procurement of parts for safety modifications. However, the term does include the installation of parts for that purpose.

## **Section 2466**

([link: return to document](#))

### **Limitations on the performance of depot-level maintenance of materiel**

#### **(a) Percentage Limitation.—**

Not more than 50 percent of the funds made available in a fiscal year to a military department or a Defense Agency for depot-level maintenance and repair workload may be used to contract for the performance by non-Federal Government personnel of such workload for the military department or the Defense Agency. Any such funds that are not used for such a contract shall be used for the performance of depot-level maintenance and repair workload by employees of the Department of Defense.

#### **(b) Waiver of Limitation.—**

The Secretary of Defense may waive the limitation in subsection (a) for a fiscal year if—

- (1) the Secretary determines that the waiver is necessary for reasons of national security; and
- (2) the Secretary submits to Congress a notification of the waiver together with the reasons for the waiver.

#### **(c) Prohibition on Delegation of Waiver Authority.—**

The authority to grant a waiver under subsection (b) may not be delegated.

#### **(d) Annual Report.—**

- (1) Not later than April 1 of each year, the Secretary of Defense shall submit to Congress a report identifying, for each of the armed forces (other than the Coast Guard) and each Defense Agency, the percentage of the funds referred to in subsection (a) that was expended during the preceding fiscal year, and are projected to be expended during the current fiscal year and the ensuing fiscal year, for performance of depot-level maintenance and repair workloads by the public and private sectors.
- (2) Each report required under paragraph (1) shall include as a separate item any expenditure covered by section 2474 of this title that was made during the fiscal year covered by the report and shall specify the amount and nature of each such expenditure.

## **Section 2470**

([link: return to document](#))

### **Depot-level activities of the Department of Defense: authority to compete for maintenance and repair workloads of other Federal agencies**

A depot-level activity of the Department of Defense shall be eligible to compete for the performance of any depot-level maintenance and repair workload of a Federal agency for which competitive procedures are used to select the entity to perform the workload.

## **Section 2474**

[\(link: return to document\)](#)

### **Centers of Industrial and Technical Excellence: public-private partnerships**

#### **(a) Designation.—**

(1) The Secretary concerned, or the Secretary of Defense in the case of a Defense Agency, shall designate each depot-level activity of the military departments and the Defense Agencies (other than facilities approved for closure or major realignment under the Defense Base Closure and Realignment Act of 1990 (part A of title XXIX of Public Law 101–510; 10 U.S.C. 2687 note )) as a Center of Industrial and Technical Excellence in the recognized core competencies of the designee.

(2) The Secretary of Defense shall establish a policy to encourage the Secretary of each military department and the head of each Defense Agency to reengineer industrial processes and adopt best-business practices at their Centers of Industrial and Technical Excellence in connection with their core competency requirements, so as to serve as recognized leaders in their core competencies throughout the Department of Defense and in the national technology and industrial base (as defined in section 2500 (1) of this title).

(3) The Secretary of a military department may conduct a pilot program, consistent with applicable requirements of law, to test any practices referred to in paragraph (2) that the Secretary determines could improve the efficiency and effectiveness of operations at Centers of Industrial and Technical Excellence, improve the support provided by the Centers for the armed forces user of the services of the Centers, and enhance readiness by reducing the time that it takes to repair equipment.

#### **(b) Public-Private Partnerships.—**

(1) To achieve one or more objectives set forth in paragraph (2), the Secretary designating a Center of Industrial and Technical Excellence under subsection (a) may authorize and encourage the head of the Center to enter into public-private cooperative arrangements (in this section referred to as a “public-private partnership”) to provide for any of the following:

(A) For employees of the Center, private industry, or other entities outside the Department of Defense to perform (under contract, subcontract, or otherwise) work related to the core competencies of the Center, including any depot-level maintenance and repair work that involves one or more core competencies of the Center.

(B) For private industry or other entities outside the Department of Defense to use, for any period of time determined to be consistent with the needs of the Department of Defense, any facilities or equipment of the Center that are not fully utilized for a military department's own production or maintenance requirements.

(2) The objectives for exercising the authority provided in paragraph (1) are as follows:

(A) To maximize the utilization of the capacity of a Center of Industrial and Technical Excellence.

(B) To reduce or eliminate the cost of ownership of a Center by the Department of Defense in such areas of responsibility as operations and maintenance and environmental remediation.

(C) To reduce the cost of products of the Department of Defense produced or maintained at a Center.

(D) To leverage private sector investment in—

(i) such efforts as plant and equipment recapitalization for a Center; and

(ii) the promotion of the undertaking of commercial business ventures at a Center.

(E) To foster cooperation between the armed forces and private industry.

(3) If the Secretary concerned, or the Secretary of Defense in the case of a Defense Agency, authorizes the use of public-private partnerships under this subsection, the Secretary shall submit to Congress a report evaluating the need for loan guarantee authority, similar to the ARMS Initiative loan guarantee program under section [4555](#) of this title, to facilitate the establishment of public-private partnerships and the achievement of the objectives set forth in paragraph (2).

**(c) Private Sector Use of Excess Capacity.—**

Any facilities or equipment of a Center of Industrial and Technical Excellence made available to private industry may be used to perform maintenance or to produce goods in

order to make more efficient and economical use of Government-owned industrial plants and encourage the creation and preservation of jobs to ensure the availability of a workforce with the necessary manufacturing and maintenance skills to meet the needs of the armed forces.

**(d) Crediting of Amounts for Performance.—**

Amounts received by a Center for work performed under a public-private partnership shall be credited to the appropriation or fund, including a working-capital fund, that incurs the cost of performing the work. Consideration in the form of rental payments or (notwithstanding section 3302 (b) of title 31) in other forms may be accepted for a use of property accountable under a contract performed pursuant to this section.

Notwithstanding section 2667 (d) [1] of this title, revenues generated pursuant to this section shall be available for facility operations, maintenance, and environmental restoration at the Center where the leased property is located.

**(e) Availability of Excess Equipment to Private-Sector Partners.—**

Equipment or facilities of a Center of Industrial and Technical Excellence may be made available for use by a private-sector entity under this section only if—

(1) the use of the equipment or facilities will not have a significant adverse effect on the readiness of the armed forces, as determined by the Secretary concerned or, in the case of a Center in a Defense Agency, by the Secretary of Defense; and

(2) the private-sector entity agrees—

(A) to reimburse the Department of Defense for the direct and indirect costs (including any rental costs) that are attributable to the entity's use of the equipment or facilities, as determined by that Secretary; and

(B) to hold harmless and indemnify the United States from—

(i) any claim for damages or injury to any person or property arising out of the use of the equipment or facilities, except under the circumstances described in section 2563 (c)(3) of this title; and

(ii) any liability or claim for damages or injury to any person or property arising out of a decision by the Secretary concerned or the Secretary of Defense to suspend or terminate that use of equipment or facilities during a war or national emergency.

**(f) Exclusion of Certain Expenditures From Percentage Limitation.—**

Amounts expended for the performance of a depot-level maintenance and repair workload by non-Federal Government personnel at a Center of Industrial and Technical Excellence under any contract shall not be counted for purposes of applying the percentage limitation in section 2466 (a) of this title if the personnel are provided by private industry or other entities outside the Department of Defense pursuant to a public-private partnership.

**(g) Construction of Provision.—**

Nothing in this section may be construed to authorize a change, otherwise prohibited by law, from the performance of work at a Center of Industrial and Technical Excellence by Department of Defense personnel to performance by a contractor.

## Appendix C: Summary of DoD Policy Documents

### **DoD Directive 4151.18**

#### **Maintenance of Military Materiel**

This directive, published by the Under Secretary of Defense for Acquisition Technology and Logistics (USD AT&L) provides guidance for the maintenance of weapon systems and specifically includes software within its purview. Key points:

- Establishes as DoD policy that “Maintenance tasks restore safety and reliability”
- Provides guidance regarding depot maintenance core capabilities.
- Core capabilities must be identified as early as possible in the acquisition life cycle and be established in the public sector not later than four years after Initial Operational Capability.
- Maintenance of all weapon systems related to that capability need not be performed in a public facility. Rather, the *capability* to perform that maintenance must be retained in those facilities.
- Exempts workloads associated with a core capability from cost studies directed by the Office of Management and Budget circular A-76 dated May 2003.
- For that portion of the maintenance workload not necessary for sustaining a core capability, factors such as cost, performance, and responsiveness should be considered.
- The source of repair selected for non-core sustaining workload should minimize risk while providing the best value to the government.



## **DoD Directive 5000.01**

### **The Defense Acquisition System**

This document is essentially an executive summary of the acquisition system. It defines the acquisition policy as existing to “... manage the nation’s investments in technologies, programs and product support necessary to achieve the National Security Strategy.” Key points:

- Identifies five attributes which govern the acquisition system: Flexibility, responsiveness, innovation, discipline, and streamlined and effective management.
- *Performance based logistics* is identified as a policy of the acquisition system.
- “Sustainment strategies shall include the best use of public and private sector capabilities through *government/industry partnering initiatives*, in accordance with statutory requirements.”

## **DoD Instruction 5000.02**

### **Operation of the Defense Acquisition System**

DoD Directive 5000.01 describes the acquisition system; DoD Instruction 5000.02 defines how the systems will be operated. While this instruction describes the entire acquisition lifecycle, this summary will focus exclusively on the operations and support phase as it is pertinent to the subject of software maintenance as a core logistics capability.

- The operations and support phase is intended to meet material readiness and operational support performance requirements in the most cost effective manner.
- Entrance into this phase occurs when a system has an approved Capability Production Document (CPD), Life-Cycle Sustainment Plan (LCSP) and a successful Full-Rate Production Decision.
- Considerations for life-cycle sustainment should include supply, maintenance, transportation, sustaining engineering, data management, configuration management, HIS, environment, safety, occupational health, protection of critical program information, supportability, and interoperability.

## **DODI 4151.20**

### **Depot Maintenance Core Capabilities Determination Process**

DODI 4151.20 interprets and implements Title 10 Section 2464.

- Defines a core logistics capability as:

The depot maintenance capability (including personnel, equipment, and facilities) maintained by the Department of Defense at government owned, government operated facilities as the ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situation and other emergency requirements. Depot maintenance for the designated weapon systems and other military equipment is the primary workload assigned to DoD depots to support core depot maintenance capabilities.
- Mirrors the intent of Title 10 section 2464 in emphasizing that the government, in time of need, will have available a workforce and facilities ready to handle increased workloads associated with a wartime scenario. This capability resides within government owned facilities and must be manned by government employees.
- Reiterates the law by designating software maintenance as a depot level maintenance function.
- Makes a distinction between capability and capacity which is central to the understanding of core.
  - *Capability* is defined as the personnel, facilities, processes and technology required to perform a particular category of work necessary to support strategic and contingency plans.
  - *Capacity* as the amount of work which can be performed within a given amount of time and is expressed in terms of Direct Labor Hours (DLH).
- The combination of capability and capacity defines both what and how much logistic support DoD must maintain to support JCS scenarios.

## **DODI 4151.21**

### **Public-Private Partnerships for Depot-Level Maintenance**

- Defines a public-private partnership for depot-level maintenance as:
  - A “cooperative arrangement between an organic depot-level maintenance activity and one or more private sector entities to perform DoD or Defense-related work and/or utilize DoD depot facilities and equipment.”
- Partnerships are directed whenever it is cost effective and can provide improved warfighter support while utilizing the government’s facilities.
- A partnership will be formed around those activities identified as core competencies.

## **Appendix D: Summary of Relevant Air Force Instructions**

### **AFPD 63-01/20-1**

#### **Acquisition and Sustainment Life Cycle Management**

This Air Force directive further refines and implements DoD acquisition policy and within the scope of this research was primarily used as a source of definitions.

### **AFI 63-101**

#### **Acquisition and Sustainment Life Cycle Management**

The purpose of this instruction is to implement the policies established in AFPD 63-01. While this document goes into great detail regarding the entire system life-cycle, this summary focuses on those aspects related to core capabilities and software specific aspects of the life-cycle. This document served as a key source of definitions relevant to our research objectives. Key points:

- A DSOR [Depot Source of Repair] decision for all depot-level maintenance for hardware and software, with special attention to Title 10 Section 2464 (core capability) and Title 10 Section 2466 (50/50 requirement), is essential to the life cycle sustainment strategy.”
- DSOR process should consider at a minimum public law, long-term depot strategy, cost, mission assignment alignment, environmental impacts, and specific weapon system requirements.
- Source of repair assignment process should be based on multiple factors and not as a competition between an organic and contract depot.

- Types of depot maintenance – programmed depot maintenance, analytical condition inspection, speedline, major overhaul and repair, repair of reparable, contract/depot field teams, over and above, extended/negotiated warranty costs, software maintenance, and disposal.
- For the purposes of satisfying Title 10 Section 2466, work done in DoD maintenance depots is defined as the workload funded through the capital working fund and accomplished by employees of the SECAF designated Centers of Industrial and Technical Excellence.

### **AFI 63-107 (SORAP)**

#### **Integrated Product Support Planning and Assessment**

This document is included in this section because the Source of Repair Assignment Process (SORAP) decision is what ultimately determines whether software will be sustained in a public or private depot. As laid out in AFI 63-101, the SORAP is designed to consider many factors when determining a source of repair such as law, long term depot strategy, cost, and system requirements. AFI 63-107 re-emphasizes that the SORAP is not a competition between public and private sources of depot maintenance.

The Program Manager (PM) is the individual responsible for initiating and completing the SORAP, and is required to consider all viable sustainment options prior to submitting a source of repair recommendation to the SORAP committee.

Five situations where SORAP is required:

1. **New Starts (New Acquisitions):** The acquisition of any weapon system, item component, system, subsystem, or software that will result in a requirement for depot-level maintenance.

2. **Modification Follow-on Workloads:** Depot maintenance workloads generated as a result of a modification installation.
3. **Overseas Workload Program:** SORAPs are required for any new, modified, or shift in source of repair that involves the potential for accomplishment of depot-level maintenance by a source outside the United States.
4. **Modifications/Reconfigurations:** The modification of a weapon system, subsystem, item or component, which is considered depot-level maintenance, is subject to SORAP requirements.
5. **Workload Shifts:** Permanent change in the officially designated source of repair, or source of modification, can only be accomplished through a SORAP when such change involves a public depot. Specifically, a SORAP is required for proposed changes in the source of repair resulting in one of the following types of shifts:
  - a. From assigned organic depot to another organic depot.
  - b. From assigned organic depot to a contract.
  - c. From contract source of repair to an organic depot.

## **Appendix E: Summary of GAO Reports**

### **Privatization and the Debate over the Public-Private Mix (GAO/T-NSIAD-96-148)**

This GAO report is a summary of the testimony before the subcommittee on Readiness and the Committee on Armed Services in the U.S. Senate. There are four general themes in this report:

- DoD's depot maintenance management model in the post cold war era
- The extent to which DoD's proposed depot maintenance policy is consistent with congressional direction and guidance.
- The savings that DoD is anticipating from privatization of depot maintenance activities.
- The cost-effectiveness of privatization-in-place as an alternative for closing depots.

This report was conducted in 1996 and therefore the context is that of a military fresh out of the Cold War and looking to re-shape itself both in combat capability as well as logistic capability. As the number of major acquisition programs decreased, the DoD became concerned that the industrial base could not be maintained and saw depot maintenance as way to keep that critical function viable. An added benefit the proponents of this policy envisioned was cost savings; assuming the private sector could perform this work more cost effectively.

Of the four main areas of this report, the examination of the consistency between DoD and congressional guidance as well as the anticipated savings from privatization are most applicable to this study in so far as they provide a history of the friction between the law and reality as well as an examination of one of the main benefits of privatization – cost.



At the time of this report, the GAO observed a clear shift in DoD policy towards private sector depot maintenance. It was the view of the GAO that this shift in policy could potentially exacerbate existing excess capacity problems and inefficiencies inherent in an underutilized depot maintenance structure. Additionally, the GAO found the DoD policy to be inconsistent with congressional guidance in the area of public-private competitions for non-core workloads.

In terms of cost effectiveness of private depots, the GAO found inconsistencies with the basis of cost comparisons leading to a more pessimistic expectation of cost savings. The GAO argued the DoD used outsourcing of such services as vehicle maintenance and food services as the basis of cost savings. The GAO used more comparable private-public program competitions and found the following:

- 67% of competitions were won by the DoD with the average bid 40% lower than the closest competitor.
- 23% of the programs no private bids were offered and 35% included only one private bid.
- 62% of items repaired by both private and public depots were maintained less expensively in the public sector.

Finally, software maintenance, while only mentioned once in the document, was a private sector function in 1996 as the following indicates:

DoD annually spends about \$15 billion—or about 6 percent of its \$243 billion fiscal year 1996 budget—on depot maintenance activities. About \$2 billion of this amount includes contractor logistics support, interim contractor support, and funds for labor associated with the installation of some major modifications and parts of software maintenance, which are contracted to the private sector using procurement, rather than operation and maintenance funds.

**DoD's Policy Report Leaves Future Role of Depot System Uncertain (GAO/NSIAD-96-165)**

This GAO report is an analysis of the *Policy Regarding Performance of Depot-Level Maintenance and Repair* report issued by the DoD and was required by section 311 of the National Defense Authorization Act of Fiscal Year 1996. This report is an in-depth analysis of the preliminary findings that were presented in GAO/T-NSIAD-96-148 *Privatization and the Debate Over the Public-Private Mix*. As such, the main points remain the same as those from the testimony previously covered.

Some additional findings in this report that are of interest to this paper are:

- DoD policy establishing total life-cycle contractor logistic support as the preferred model for maintaining new systems not identified as core.
- DoD policy shift toward a greater mix of private depots which is reflected by:
  - A call for minimum core requirements
  - Redefining core to allow for privatizing mission essential requirements previously defined as core.
  - Limit public depots from competing with the private sector for noncore workloads.
  - Provide a preference for privatizing depot maintenance and repair for new systems.
  - Provide disincentives for depots to compete.
- DoD policy moved source of repair decisions from service logistics chief (in conjunction with functional organic depot maintenance and business managers) to the service acquisition representative responsible for a new weapon system.
- Identifies core capabilities as required to sustain in-house technical competence-skilled maintenance workers, engineers contracting officials and program managers-to minimize technological risks.

**More Comprehensive and Consistent Workload Data Needed for Decisionmakers**  
**(GAO/NSIAD-96-166)**

This GAO report is the assessment of the DoD report *Depot Maintenance and Repair Workload* required by section 311 of the National Defense Authorization Act for Fiscal Year 1996. The report focused on the following areas:

- The need for and effect of the 60/40 legislative requirement concerning the allocation of depot maintenance workloads between the public and private sectors.
- Historical public and private sector depot maintenance workloads allocations.
- Projected public and private depot maintenance workload allocations.

Of note from this report, the Air Force, in 1997, was projected to have a public-private mix of depot maintenance of 46/54. Additionally, the GAO reported that the Air Force intended to privatize five prototype workloads, one of which was software.

**Uncertainties and Challenges DoD Faces in Restructuring Its Depot Maintenance Program (GAO/T-NSIAD-97-112)**

This testimony before the House of Representatives Subcommittee on Readiness and the U.S. Senate Committee on Armed Services covered four main areas.

- DoD plans for eliminating costly depot maintenance excess capacity.
  - DODs progress in finalizing a new depot workload allocation policy.
  - DODs current approach for allocating maintenance workloads for new and existing systems.
  - DoD estimates that billions can be saved by outsourcing depot maintenance.
- This report highlights the fact that in 1997, policy regarding mix of public-private

workload and, to a lesser extent, identification of core depot maintenance capabilities was very much in flux. In fact, the report states that program officials from the C-17, F-22, and F/A-18E/F were delaying final support decisions in part because of the uncertain status of DoD core policies.

Additionally, the testimony evolved its definition of depot maintenance to read:

Depot maintenance is a vast undertaking that requires extensive shop facilities, specialized equipment, and highly skilled technical and engineering personnel to perform major overhauls of weapon systems and equipment, to completely rebuild parts and end items, to modify systems and equipment by applying new or improved components, to manufacture parts unavailable from the private sector, and to program the software that is an integral part of today's complex weapon systems.

This definition conspicuously omits the term maintenance after the word software and insinuates that depot maintenance involves all manner of software programming.

## **DoD Shifting More Workload for New Weapon Systems to the Private Sector**

### **(GAO/NSIAD-98-8)**

This report is one in a series of reports by the GAO addressing DoD's depot maintenance policies, outsourcing plans, depot closures, and the allocation of work between the public and private sectors.

This report once again highlights an ongoing debate between DoD and Congress regarding the size, composition, and allocation of depot maintenance workload between the public and private sectors. A 1995 report by the Commission on Roles and Missions titled *Directions for Defense* estimated the DoD could reduce depot maintenance costs by 20-40% by outsourcing work in a competitive environment. The GAO disagreed with this assessment charging that in some cases outsourcing practices could actually increase the cost of depot maintenance. In response to this debate, the 1998 Defense Authorization Act provided the following changes to various depot maintenance requirements:

- Created section 2460 in Title 10 establishing a statutory definition of depot-level maintenance which included, among other types of work, certain software maintenance while excluding major system upgrades.
- Amended 10 U.S.C. 2464 to provide for a DoD-maintained core logistics capability that is required to be government owned and operated.
- Amended 10 U.S.C 2466 to allow DoD to use up to 50 percent of its depot maintenance funds for private sector performance of work

The GAO research showed that as of 1997, 13 of 25 major Air Force acquisition programs had either selected or were leaning towards private sector depot maintenance constituting 52 percent of the programs studied. This is compared to just 4 of 25, or 16 percent, selecting or leaning towards the public sector. In addition, the report states the

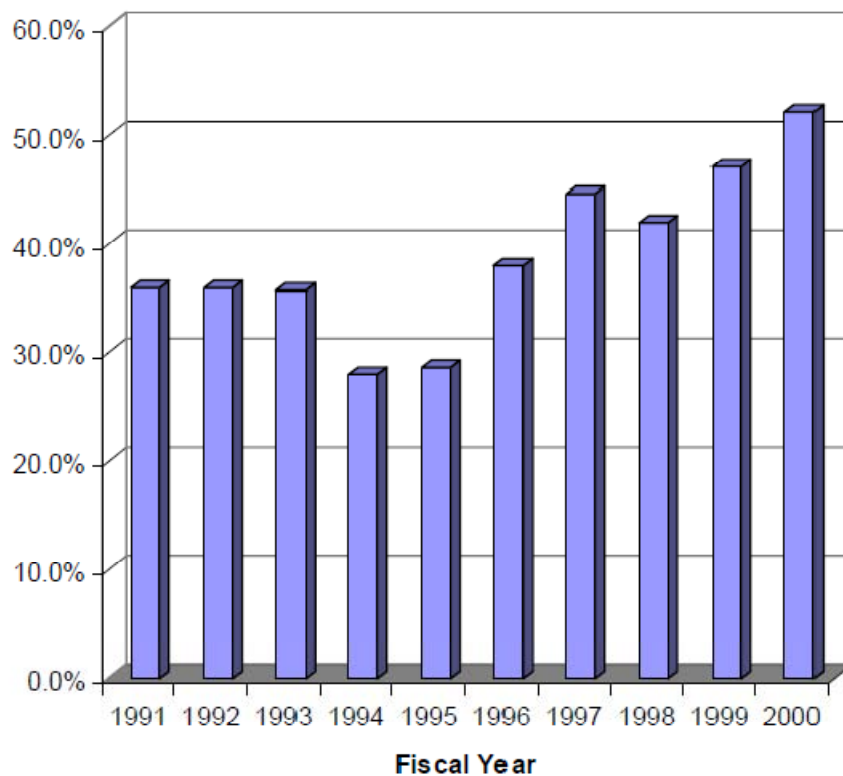
C-17 program put off a decision on its source of repair until 2003 or later because of uncertainty with DoD policies.

Also of note in this report was that nearly 76 percent of program managers DoD wide that had finalized their source of repair decision (1) did not plan to assess core and were moving ahead without a core determination (2) were unsure of their plans or (3) were uncertain about how or whether to consider core. Some even responded they were not sure what the term “core” meant.

Finally, the GAO found that many programs were not planning to buy technical data that could help them avoid sole-sourcing maintenance work to the contractor that developed the system. There were varying reasons for not purchasing data rights typically centering on the cost associated with the data coupled with a perceived lack of need. Ultimately, the GAO assessed not purchasing the technical data would result in a higher life-cycle support cost and difficult logistics decisions in the future.

**Air Force Faces Challenges in Managing to 50-50 Ceiling (GAO/T-NSIAD-00-112)**

The data in this GAO report is a result of testimony before the U.S. House of Representatives Subcommittee on Readiness, and the U.S. Senate Committee on Armed Services. The content of this testimony deal exclusively with a fiscal year 2000 waiver request to the 50/50 rule by the Secretary of the Air Force. The only useful data to this paper from the GAO report is contained in Figure 32, which shows the trend of increasing contractor involvement in depot maintenance.



**Figure 32. Contractor Depot Maintenance Workload Allocations from 1991 to 2000**

**Air Force Report on Contractor Support is Narrowly Focused (GAO/NSIAD-00-115)**

This report to Congressional Committees was in response of section 344 of the National Defense Authorization Act for Fiscal Year 2000 which required the Secretary of the Air Force to provide a report to Congress identifying all Air Force programs that were currently using or planning to use Total System Performance Responsibility (TSPR) or similar contractor support programs. Additionally, the Air Force report was to, among other things; evaluate how these programs support warfighting readiness and the process and criteria used by the Air Force to determine whether government or the private sector can perform logistics management functions more cost-effectively. The GAO was then tasked to evaluate the Air Force report to Congress.

Much of this GAO report was outside the purview of this paper. There was one finding of interest concerning government depot maintenance, however. In the process of evaluating how programs such as TSPR might affect core logistics management, the GAO identified a concern within Air Force Material Command that depots were not receiving work involving new, advanced technology weapon systems they would need to have if they were to establish and maintain core capabilities in these areas. An excerpt from a 9 Feb 2000 memorandum from the Ogden Air Logistics Center to Headquarters, Air Force Materiel Command stated:

Infusion of new technology workloads from new weapon systems is essential to maintain core. Therefore the future of the [air logistics center] is contingent upon acquiring workloads in each technical repair center that will continue to provide a viable organic source of repair for the using commands. If an [air logistics center] is determined core or best value in a particular technology, then any new weapon system acquired that has the



associated technology should have the respective core allocation from day one of the sustainment life cycle. The core determination is weighted heavily towards older high surge workloads. Depots are provided new workloads often only after the original equipment manufacturer loses interest. [pg 13]

#### **Air Force Waiver to U.S.C 2466 (GAO/NSIAD-00-152R)**

This GAO letter to members of the House of Representatives is an assessment of the Air Force waiver to 10 U.S.C 2466 which caps at 50 percent all depot maintenance expenditures within the private sector per fiscal year. This letter serves to highlight an ongoing privatization trend within the Air Force in the early 2000's.

A noteworthy finding in this GAO letter was a massive increase in private sector depot maintenance spending in a four year period. In 1996, the Air Force spent approximately \$600 million on long-term depot maintenance contracts for new systems. By 2000, however, that number had increased to \$1.1 billion, an increase of 83 percent. It also showed this trend to continue at least through 2004 with an average of 48 percent allocation of depot maintenance workload to the private sector during that timeframe.

**Actions Needed to Overcome Capability Gaps in the Public Depot System (GAO-02-105)**

This GAO report to Congressional Committees was in response to concern from members of Congress about the need to continue the performance of mission-essential, or core, maintenance activities in military depots and the long-term viability of military industrial facilities in light of the DoD's increased reliance on the private sector to accomplish logistics support activities such as the maintenance of weapon systems.

One area of concern to the GAO was the DoD's use of "like" workloads to satisfy the core requirements. The GAO used the example of the DoD using workload on the C-141 and C-5 to satisfy core capability workload on the C-17. The DoD's provided an analogy of an auto mechanic who can perform work on Chrysler, Ford, and General Motors products, if the mechanic has tools, facilities, and knowledge. They asserted the skills, facilities, and knowledge are transferable and the same holds true within the DoD.

Additionally, the GAO found fault the DoD's use of a risk assessment when determining whether maintaining a system was core. The GAO found that the DoD was assessing whether the private sector could provide logistics capability for mission essential items at an acceptable level of risk. Further, GAO found that this type of risk assessment was not consistent with U.S.C. 10 2464 and ultimately the DoD agreed to remove risk from its core determination process.

Finally, this report identified shortfalls within the DoD, and the Air Force specifically, in the area of software maintenance. In 2001, for example, the Air Force forecast an 800,000-hour shortfall in depot-level software maintenance workload. The

shortfall was primarily due to a lack of capability to accomplish that much workload. Air Force officials repeatedly identified shortfalls in qualified software technicians and engineers as one of their most severe concerns at the depots [pg 23]. While recruiting in general was not a problem for the depots, officials did note difficulty in hiring workers with software maintenance skills. A national shortage, at the time, of software engineers meant the depots were competing with the private sector for workers.

**DoD Should Strengthen Policies for Assessing Technical Data Needs to Support Weapon Systems (GAO-06-839)**

This GAO report to Congressional Committees highlights the implications of changing policies and laws on programs with long acquisition timelines. It also highlights the need to purchase technical data rights for effective system life-cycle sustainment. In particular, this section will highlight the plight of the F-22, although the GAO raised similar issues with other programs contemporary to the F-22.

*F-22 aircraft:* The acquisition of the Air Force's F-22 aircraft did not include all of the technical data needed for establishing required core capability workload at Air Force depots. Early in the F-22 aircraft's acquisition, the Air Force planned to use contractors to provide needed depot-level maintenance and therefore decided not to acquire some technical data rights from sub-vendors in order to reduce the aircraft's acquisition cost. Subsequently, however, the Air Force determined that portions of the F-22 workload were needed to satisfy core depot maintenance requirements. The Air Force is currently negotiating contracts for the technical data rights needed to develop depot-level maintenance capability. While the Air Force has negotiated contracts to acquire technical data for four F-22 aircraft components, F-22 program officials expressed concern that it may become difficult to successfully negotiate rights to all components.

Additionally, the GAO identified several factors which may complicate program managers' decisions on long-term technical data rights for weapon systems. These factors include the following:

- The contractor's interests in protecting its intellectual property rights. Because contractors need to protect their intellectual property from uncompensated use, they often resist including contract clauses that provide technical data rights to the government.
- The extent to which the system being acquired incorporates technology that was not developed with government funding. According to DoD's acquisition guidance the government's funding of weapon system development determines the government's rights to technical data. Weapon systems are frequently developed with some mix of contractor and government funding, which may present challenges to DoD in negotiating technical data rights with the contractor.
- The potential for changes in the technical data over the weapon system's life cycle. The technical data for a weapon system may change over its life cycle, first as the system's technology matures and later as the system undergoes modifications and upgrades to incorporate new technologies and capabilities. The potential for changes in technical data present challenges concerning when the government should take delivery of technical data, the format used to maintain technical data, and whether the data should be retained in a government or contractor repository.
- The extent to which the long-term sustainment strategy may require rights to technical data versus access to the data. According to Army officials, access to contractor technical data is sometimes presented as an alternative to the government taking delivery of the data. These officials noted that while access to technical data may allow for oversight of the contractor and may reduce the program manager's data management costs, it may not provide the government with rights to use the technical data should a change in the sustainment plan become necessary.
- The numerous funding and capability trade-offs program managers face during the acquisition of a weapon system. Program managers are frequently under pressure to spend limited acquisition dollars on increased weapon system capability or increased numbers of systems, rather than pursuing technical data rights.
- The long life cycle of many weapon systems. With weapon systems staying in DoD's inventory for longer periods—up to 40 years, it may be difficult for the

program manager to plan for future contingencies such as modifications and upgrades, spare parts obsolescence, diminishing manufacturing support, and diminishing maintenance support.

**DoD Needs to Reexamine Its Extensive Reliance on Contractors and Continue to Improve Management and Oversight (GAO-08-572T)**

This GAO report is a summary of testimony provided before Subcommittee on Readiness and the Committee on Armed Services of the House of Representatives. It takes a broad look at core capabilities throughout the DoD, not just focusing on core logistics capabilities. The report does, however, spend some time analyzing the challenges facing the DoD with respect to developing core logistics capabilities and specifically how much work should be done in-house and to what extent outsourcing of labor has been cost effective.

The GAO cites three factors as influencing the DoD trend toward contractor support for depot level maintenance: 1) DoD guidance emphasizing outsourcing 2) A lack of technical data and modernized facilities to perform work on new systems 3) Reductions in maintenance workers at government facilities. In fact, the GAO cites a 246 percent increase in funding for private sector contracts for depot maintenance between 1987 and 2000. The funding for public depots, however, increased by only 89 percent during the same timeframe; a clear indication of the shift in emphasis away from in-house maintenance.

Another significant finding by the GAO is that the DoD did not, as of 2008, had not comprehensively identified what depot maintenance should be performed in-house. This made it difficult for the GAO to determine what maintenance activities being performed by contractors should in fact be done by government personnel.

## **Issues and Options for Reporting on Military Depots (GAO-08-761R)**

This briefing to Congressional Committees was in response to the 2008 National Defense Authorization Act which required the GAO to review and make recommendations regarding the reports, assessments, analyses, and documents used for determining the compliance of the Department of Defense (DoD) and military departments with the percentage limitation in 10 U.S.C. 2466 -frequently referred to as the 50/50 requirement.

The briefing had three key objectives. Objective 3 is of particular interest to this paper as it offers Congress some key issues to consider in the ongoing debate over the correct mix of private and public workloads as well as core capabilities. The issues, as laid out by GAO are:

- To what extent are 50/50 and core still relevant for assessing a required level of organic maintenance capability?
- What role are the depots to have in DoD weapons system support? Are they to be only used for legacy systems and as repairers of last resort when a contractor is not available, or are they to be a key source of repair for new and modified weapon systems?
- How does core depot maintenance fit into a DoD support scenario in light of DoD's preference for using performance-based logistics?
- If the maintenance depots are to remain relevant in the future, what actions are needed to ensure they are modernized and capable of performing maintenance on new systems?
- As it becomes more difficult to distinguish depot from intermediate maintenance and maintenance from other supportability functions, to what extent does it remain practicable to quantify a balance of public and private sector depot maintenance?
- Is it important for DoD to continue to define some level of core capability that it should perform using DoD military or civilian employees?

- What kind of capability, if any, should DoD retain in organic depots to assure that they have a ready and controlled source of technical competence and the resources necessary to ensure its ability to respond to current and future national defense emergencies?
- To what extent should the depots be capable of performing maintenance on weapon system commodities?
- How would DoD assure that maintenance would continue to be cost effective if the depots were no longer available as an alternative source of repair?
- Should there continue to be a required level of organic logistics capability and if so should it be only for maintenance?
- What changes can be made to the 50/50 and or core process to improve their accuracy and internal controls?
- Could a modified strategic-level core process be developed to simplify the development of required information regarding essential capabilities to be retained in the military depots?



**DoD's Report to Congress on Its Public-Private Partnerships at Its Centers of Industrial and Technical Excellence (CITES) Is Not Complete and Additional Information Would be Useful (GAO-08-902R)**

This GAO report was authored for the chairman and ranking member of both the Senate and House of Representatives Committee on Armed Services. The content of the report is an assessment of the DoD report to Congress on public-private partnerships at its CITES and contained the following six reporting elements: (1) common approaches and procedures for DoD CITES to use in the implementation of partnerships; (2) consistent cost methodologies and reimbursement guidance applicable to maintenance and repair workload performed by federal personnel participating in public-private partnerships; (3) implementation procedures for completing contract negotiation for partnerships within 12 months of initiating negotiations; (4) the secretary's use of commercial practices in partnerships to replace existing inventory and component management, technical publication data, document management, equipment maintenance, and calibration requirements; (5) delegation during a partnership of Class 2 design authority<sup>1</sup> based on commercial practices to maintain the form, fit, and function of a weapons system platform, major end item, component of a major end item, or article; and (6) plans to expand core capabilities through the use of partnerships at DoD CITES.

Of note in this report is the GAO description of private-public partnering. The GAO describes these partnerships as cooperative arrangements between a depot-level maintenance activity and one or more private sector entities to perform DoD or defense-related work, to utilize DoD depot facilities and equipment, or both.

**Actions Needed to Identify and Establish Core Capability at Military Depots (GAO-09-83)**

This report to the Subcommittee on Readiness of the House of Representatives Committee on Armed Services provided some keen insight into the emerging issues between software maintenance and core capabilities.

The most significant issue identified in this paper involved the Navy's handling of software maintenance. The Navy contended that software maintenance is not maintenance in the pure sense of the word as it does not return an item to its original working condition. The Navy further argued that

...when a problem caused by a component failure is found in hardware, the solution entails bringing the hardware item back to its original configuration — whereas in the case of software, when a problem is found and corrected, a new configuration is created. Given that, command officials felt that the classic organic depot scenario of an artisan using tools to restore an item to its original condition would never apply in the software world, and a more appropriate term than software maintenance would be software support. Further, the officials felt that the work reserved for organic depots under the core statute is a subset of a much larger world defined by Section 2460, and “software maintenance” is depot maintenance in this broader sense, rather than in terms of the core statute.

The point raised by the Navy is key and can easily become confusing. The legislation the Navy refers to simply defines what constitutes depot maintenance and does not mention core capability. Section 2464 of Title 10, defines what constitutes a core capability but never mentions the word depot directly, although it is common understanding that is what the statute is referring to. The point of the Navy's argument is

that while all core capabilities are depot maintenance, not all depot maintenance constitutes a core capability.

The GAO disagreed with the Navy's assessment and ultimately the DoD did as well. The Navy, as of this writing, is in the process of establishing a core capability for software maintenance within their depots.

## **Appendix F: QuOAT Interview Questions**

- 1. Which of the following best characterizes your next OFP release compared to your last OFP release (with respect to requirements):**
  - a. No new requirements
  - b. Few new requirements
  - c. Many new requirements
  - d. Extensive new requirements
  
- 2. Which of the following best characterizes your next OFP release compared to your last OFP release (with respect to the baseline affected by the changes):**
  - a. Only product baseline affected
  - b. Product and/or allocated baseline affected
  - c. Product and allocated baseline affected
  - d. Product and/or allocated and functional baseline affected
  
- 3. Which of the following best characterizes your next OFP release compared to your last OFP release (with respect to capabilities related to the aircraft mission or functionality of the OFP):**
  - a. No new capabilities/functionality added
  - b. Few new capabilities/functionality added
  - c. Many new capabilities/functionality added
  - d. Extensive new capabilities/functionality added
  
- 4. Which of the following best characterizes your next OFP release compared to your last OFP release (with respect to how software complexity might be measured on your aircraft):**
  - a. No change or decreasing complexity of the OFP
  - b. Minimal increase in complexity of the OFP
  - c. Large increase in the complexity of the OFP
  - d. Extensive increase in the complexity of the OFP
  
- 5. Which of the following best characterizes your next OFP release (with respect to testing required prior to operational use):**
  - a. Bench testing only
  - b. Minimal flight testing
  - c. Moderate flight testing
  - d. Significant flight testing

**6. Was new operator training, qualification, or documentation required to use the new OFP?**

- a. No
- b. Yes

**7. Which of the following best characterizes your next OFP release with respect to adding hardware to the aircraft associated with the OFP (weapons, processors, radar, etc):**

- a. No
- b. Yes

**8. Which of the following best characterizes your next OFP release compared to your last OFP release (with respect to time between OFP releases):**

- a. < 12 months between releases
- b. 12-18 months between releases
- c. 18-24 months between releases
- d. > 24 months between releases

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